Instruments

THE MAGAZINE OF

Measurement and Control

Vol. 17
FEB. 1944
No. 2

INCLUDING

Aviation Instruments

BAROMETERS
Mercurial

CONTROLLERS
Flow
Humidity
pH
Liquid Level
Pressure
Temperature
Vacuum

FLOW INSTRUMENTS
Controllers
Indicators
Integrators
Meters
Recorders

GAGES, RECORDING
Pressure
Temperature
Vacuum

HYDROMETERS

HYGROMETERS
Wet & Dry Bulb
Thermometers

LIQUID LEVEL
Controllers
Indicators
Recorders

MERCURIAL GAGES
Absolute Pressure
Mercurial Vacuum

MOISTURE METERS
Grains, Tobacco,
Wood, Granular
Material

OIL TESTING INSTRUMENTS

POTENTIOMETERS
Controlling
Indicating
Recording

PYROMETERS
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Recording
Resistance
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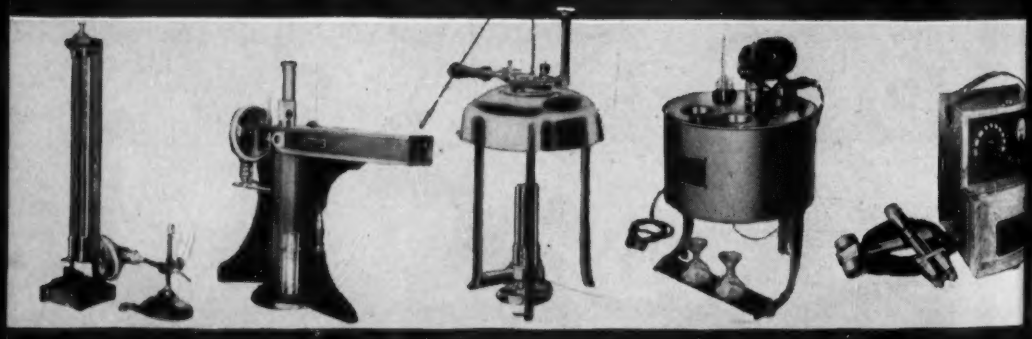

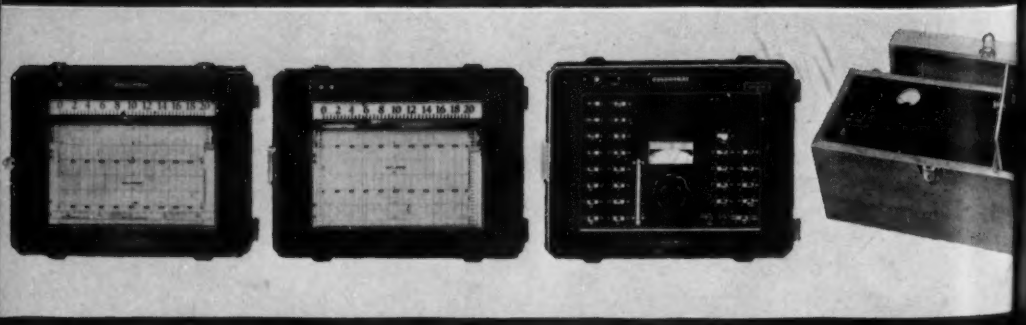

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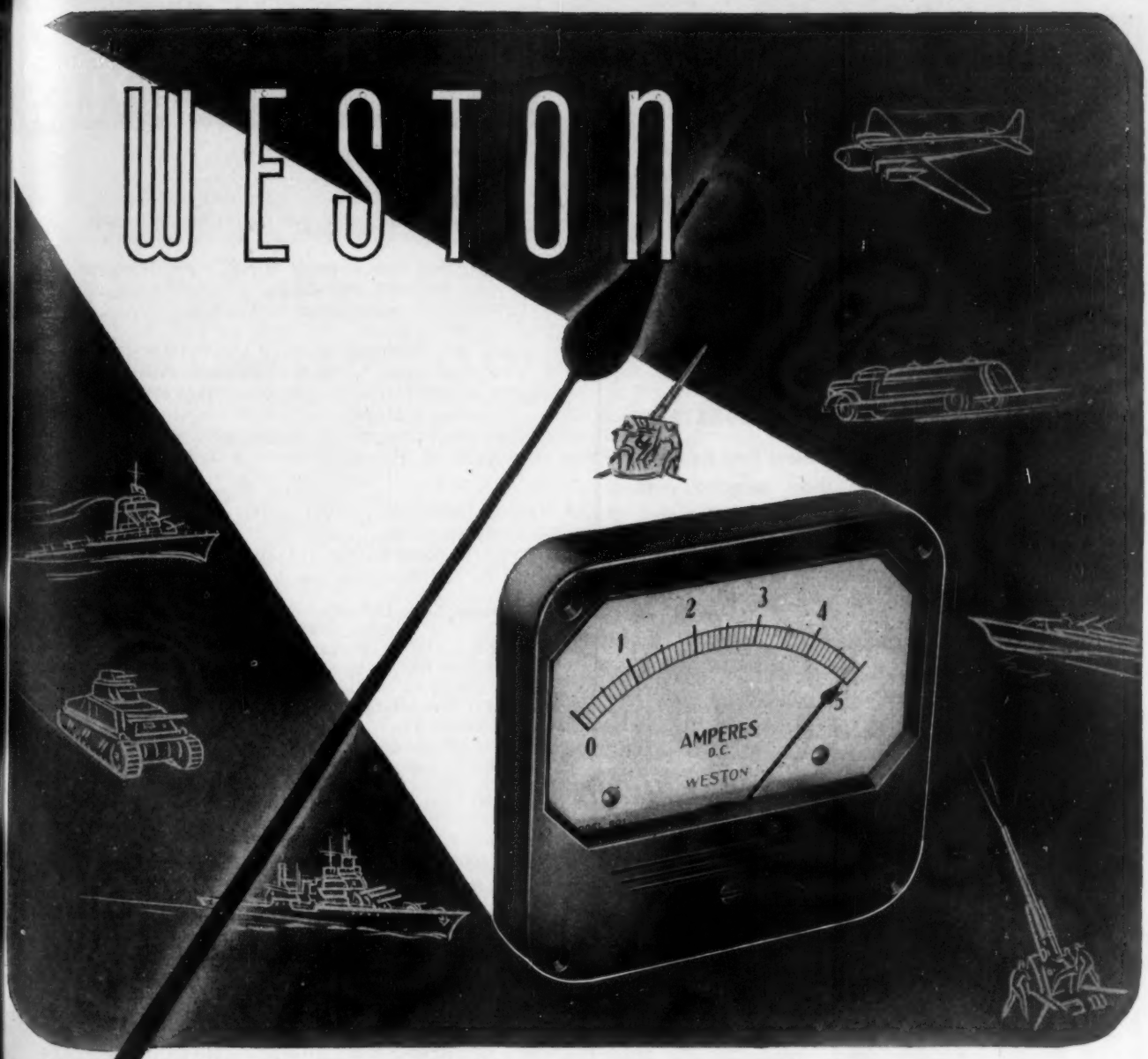

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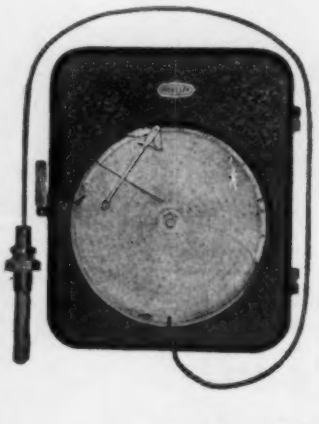

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Instruments THE MAGAZINE OF Measurement and Control

M. F. BEHAR, Editor

An Inspiring Analysis of Educational Problems Pertaining to Instruments

AUSTRALIA'S population is about seven million; that of the State of Victoria less than two million; yet it is in Melbourne that some of the world's most progressive Instrumenticians are to be found. We have already taken pleasure in reporting their formation of an Australian Society of Instrument Technology; now we have just received a letter and an enclosure, both of which we print in full as an "editorial" on instrument education problems which is largely applicable to conditions in the United States. Indeed, take away the England-to-Australia distance factor and you have a good analysis of American conditions. —MFB

To the Editor of *Instruments*:

The Director of Industrial Training of the State of Victoria is investigating the probable post-war changes in technical education that will be needed to meet the great technological changes and developments brought about by the tremendous expansion in industry due to the war. This is in accordance with a resolution of the Australian Council Conference, May 1943.

A Committee has been appointed to investigate the probable changes in the field of the optical and scientific instrument manufacturing industry. This Committee submitted its Syllabus to me for an expression of opinion. As part of my reply I prepared a memorandom, a copy of which is enclosed.

This memorandum may be of some interest to you and you are at liberty to make any use of it that you may desire. P. A. CRIVELLI.

Melbourne, C.1, Australia
9th December, 1943.

[*Enclosure*]

MEMORANDUM ON TECHNICAL TRAINING FOR THE INSTRUMENT INDUSTRY

(1) When some branch of human endeavor has developed gradually through the ages it carries with it traditions and customs that die only very reluctantly, and long after they have lost all meaning and purpose. New industries and services build up an entirely new structure to serve themselves, and the function and purpose of their tools, or the words they use, are strange and incomprehensible to the man in the street.

(2) In the early days of philosophical experiment instrument making was a trade restricted to the equipment of research. The only market for the instrument maker's services was obviously the Academies and Universities.

(3) Today the name "Instrument Making" is given to a host of entirely different occupations, just as different as those covered by the word "Engineering." There is no practical connection between a man making fused quartz laboratory ware, or glass thermometers, and the man making an electron microscope, or a recording potentiometer. There we strike right at the root of the matter, a recording potentiometer is not made by a man at all, it is made by a factory, with an organization. In that factory are electricians, mechanics, fitters, draughtsmen, managers, typists, calibrators, cost clerks, turners, drillers, and so on. If the Company describes itself as "Instrument Makers" what are the employes? Are they Instrument Makers too?

(4) In other words, the trade of Instrument Making is still the same old trade of instrument making, but the name is also used in a weak attempt to cover something that will not be covered. Except by a comparatively few individuals it is not yet realized that an entirely new branch of technology has arisen within the last few years. Nevertheless it has arisen, there is no doubt about that, and it is developing at about the same rate as the aviation and radio industries. Its geographical position on the map of science and industry is just mid-way between physics and engineering. In America it is called Instrumentation; in Australia, if it yet has a name, that name is Instrument Technology.

(5) The history of this new technology will bring to light some points that will be useful when we come to the matter of training and education, so it is worth consideration.

When it became apparent that research is essential to the well-being of industry it became necessary, at the same time, to give industry the tools to carry out the specifications written by research. For instance, the manufacturer of aircraft wants duralumin

(Concluded on page 116)

Instrumentation to Be Emphasized at M.I.T.

HERE is a quotation from the recently - printed pamphlet summarizing President Karl T. Compton's Annual Report on the Massachusetts Institute of Technology:

"Added Emphasis on Specific Fields. As a result of visiting committee and faculty studies in recent years . . . desirability of increased emphasis on certain aspects of our curriculum . . .

"Instrumentation. The ingenious design of special instruments along sound engineering lines is partly dependent upon native ingenuity and partly upon sound scientific and engineering training. Because we are the type of institution which we are, and because we have been unusually fortunate in having on our staff individuals who combine native ingenuity and sound training in a remarkable degree, the invention and development of instruments has been one of our lines of notable achievement. In fact, we have been given both moral and practical encouragement from a very important governmental user of highly technical instruments, in order that we may serve as a still more effective center for developing instruments and for training instrument designers. As a step to promote further progress in this field the Executive Committee has recently set aside the sum of $25,000, again to permit prompt action on new opportunities in this direction. Furthermore, we plan, in the near future, to assign an interdepartmental group the responsibility for the further development of our educational program in this highly important field, which is on the one hand specialized but on the other hand very wide in the scope of its applications."

Although I am not an M.I.T. man I salute this great institution and its far-seeing president for thus proclaiming to the educational world—and to industry—not only recognition of Instrumentation but *increased emphasis on Instrumentation in the curriculum.* Truly, there has been a change, not only at M.I.T. but throughout the engineering world, since the nineteen-twenties when every engineering educator, engineering society official, science publisher, etc., to whom I tried to "preach the gospel of Instrumentation" denied that there existed such a branch of engineering. The predictions which drew ridicule on my head are all coming true. —MFB

Up to now, all that was known to the public (and only along certain railroads) was the external appearance of the trailers: prepared and sealed in the contractor's shop for deck loading on ships.

COVER PHOTO shows detailed inside view

ASC's Ingenious Semi-Trailer Brings Instrument Shop Facilities Overseas

A "secret weapon" of our Army Air Forces—the marvelously quick repair of instruments—is the combination of two secrets: special training and special mobile shops. We have printed articles by AAF instructors partly disclosing the first secret; here is the first official disclosure of the second secret —prepared exclusively for *Instruments*.

AIR SERVICE COMMAND, the Army Air Forces' maintenance and supply component, announces that quantity production has been started on its Semi-Trailer designed to provide complete facilities for test, calibration and minor repair of all aircraft instruments and air-driven gyropilots. This new time-saver (hence a saver of American lives) was completely outfitted and arranged by personnel of the Maintenance Division, ASC, AAF. While primarily intended to accomplish First, Second, and Third Echelon maintenance, it provides sufficient equipment to accomplish Fourth Echelon ("heaviest") work if required. Wherever requirements exist for instrument shops capable of handling a relatively limited quantity of work, these trailers serve to good advantage. Such requirements exist primarily overseas in Air Service Command units.

One peculiarity of aircraft instrument test and calibration requirements is the close relationship of various items of equipment, many of which have to be inter-connected. This condition does not exist in Engineering Shop trailers where a lathe or milling machine is used as an isolated unit. In instrument test and calibration it is necessary, for example, that a source of vacuum or compressed air be connected into vacuum chambers, manometers, gyro test fixtures and other openings by a system of gas-tight piping and sensitive needle control valves which form an inter-connected assembly. This system is absolutely necessary for satisfactory test and calibration of air-speed indicators, rate-of-climb indicators, altimeters, manifold pressure indicators, vacuum gages, gyro instruments and automatic pilots. The same situation exists in regard to electrical instruments, particularly position indicators such as the Autosyn: mechanical devices of various kinds are required to actuate the transmitter units while electrical tests are being made. Supplies of direct and alternating current, of various voltages and frequencies, must be available at convenient locations.

For these reasons, among others, it is highly desirable that all equipment in the Instrument Trailer be assembled and fitted up according to the best possible practice. Fragile or delicate items are shock-mounted and connected permanently. It is obvious that this cannot be accomplished under field conditions. All of the necessary work is being accomplished in the contractor's plant by assembly-line methods under close inspection of AAF Inspectors. Each trailer unit is thoroughly prepared internally against salt-water corrosion for overseas shipment. Loose items are packed and secured to the floor. Internal bracing is provided to prevent damage due to vibration or movement on shipboard. All trailer openings are sealed with specification sealing material and coated with a specification corrosion-resisting agent. The Instrument Shop is ready for immediate use after the removal of internal bracing and protective coatings.

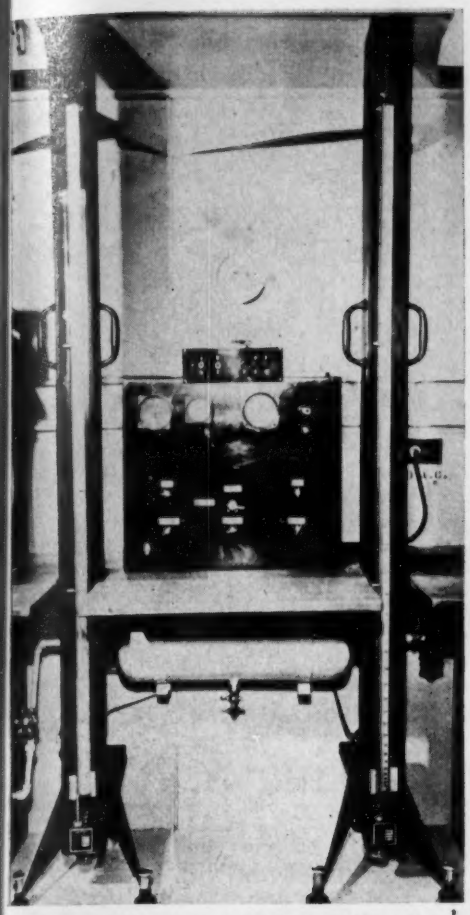
Adequate heating and air-conditioning facilities, built into the unit, assure the comfort of personnel as well as proper temperature, low humidity and clean air for satisfactory instrument servicing and repair. On the world fronts, these advantages are marked.

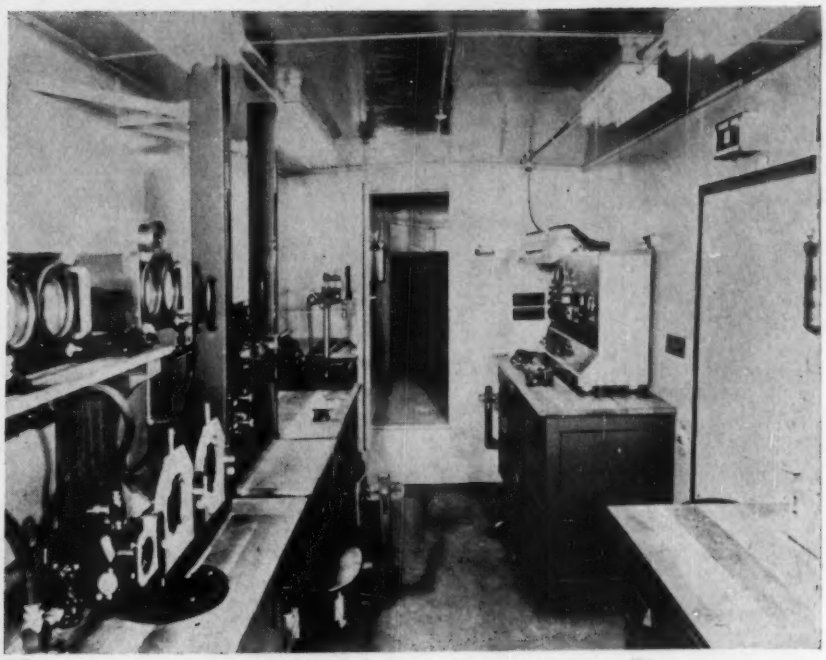
Ample storage space is available for spare parts as well as repairable instruments. Space is provided also to accommodate additional items of equipment for test and calibration of certain types of position indicators and fuel-level indicators, when such equipment is available. However, the volume of this work is necessarily less because of dimensional restrictions.

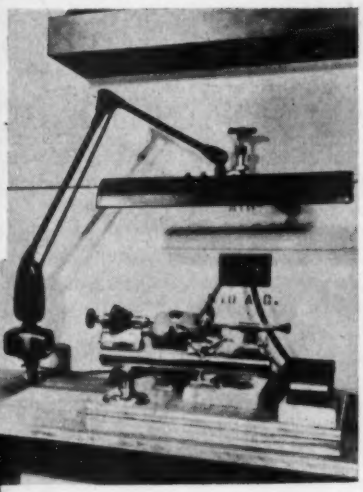
Hand tools are not included, inasmuch as they are a part of the ASC Instrument Mechanic's Kit.

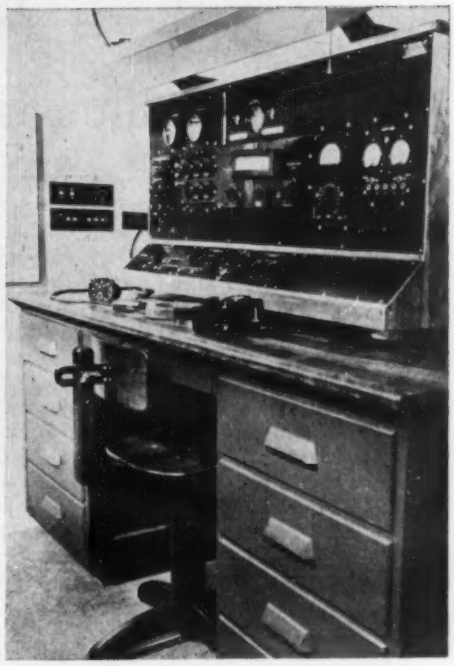
The size and weight of the trailer are a partial disadvantage in water transportation. Also some difficulty is encountered when maneuvering in deep sand. (One of these shops was taken across 2000 miles of semi-jungle country, over roads cut through the bush.) But it is believed that the completeness of the Instrument Semi-Trailer will far outweigh the disadvantages encountered in transportation, especially at airfields where fighting craft are based or where it is not practical to construct shelters by reason of tactical movements.

The unit is an indication of Air Service Command's determination to lick its world job of maintenance and supply by streamlined methods.

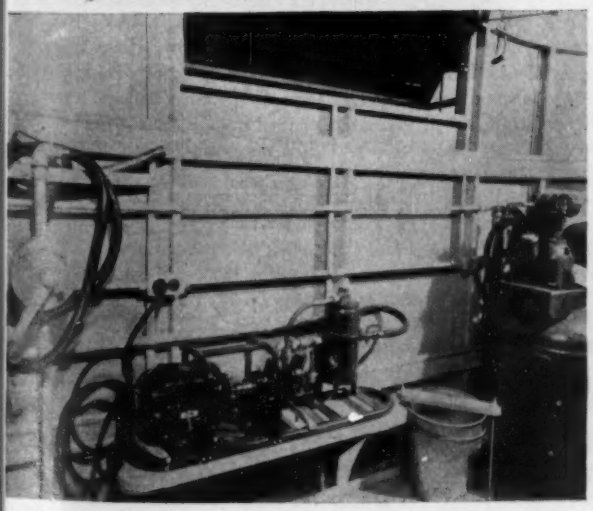


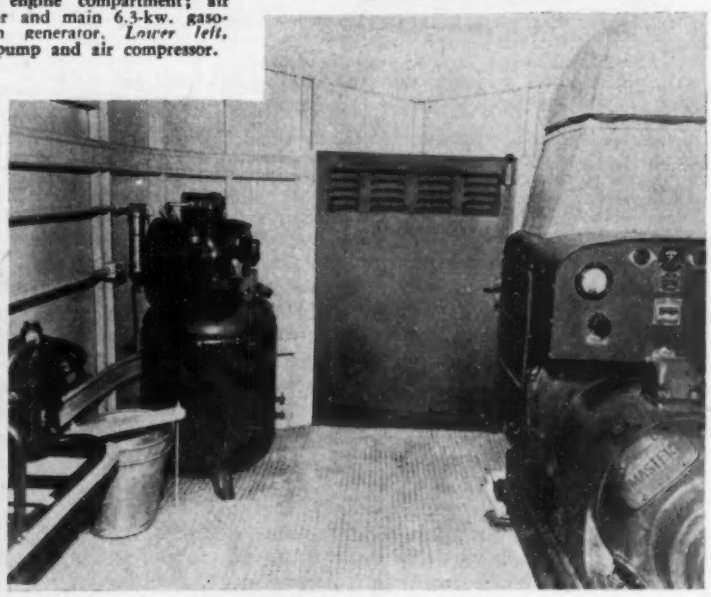






Upper left. Close-up of shock-mounted manometers for testing air-operated instruments. *Upper right.* General view looking forward into engine compartment. *Left.* Extreme rear: thermometer and pressure gage testers, and work-bench. *Right.* Close-up of electrical test panel. *Lower right.* View of engine compartment; air compressor and main 6.3-kw. gasoline-driven generator. *Lower left.* Vacuum pump and air compressor.





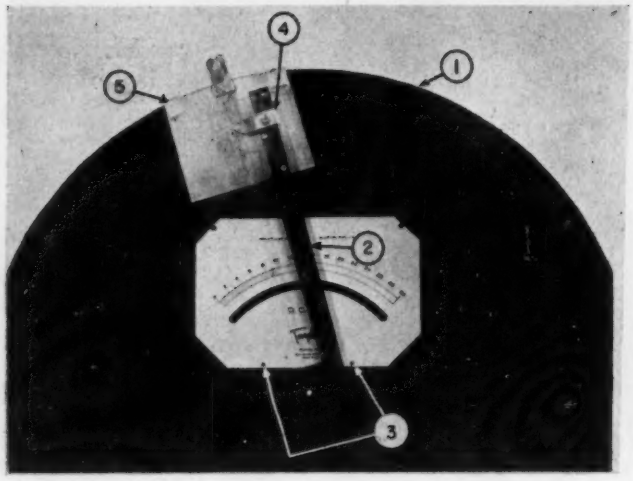


Fig. 1. Scale drawing board with instrument dial in position.

Fig. 2. Bakelite ruler (2) with index pin (4).

Fig. 3. Index plate (5), approximately full-size.

Easily-built Machine for Hand-marking Scales

By FRED J. LINGEL, Engineering Dep't, The Triplett Electrical Instrument Co., Bluffton, Ohio

IN order to facilitate the drawing of hand-stepped instrument scales such as those necessary for accuracies of 1% and higher, a simplified drawing machine was constructed as described below. This device will be found extremely useful in instrument service stations and engineering laboratories where it becomes necessary to restep precision instruments. It consists essentially of a flat board on which the dial is securely mounted with a suitable pivoted ruler for drawing the lines. A pin adjusted to slide on the ruler is located near its upper edge in such a way as to index into grooves cut in a brass plate snapped over the upper edge of the board. The first groove on this brass plate is located directly on a radius. The remaining ten grooves corresponding to a total of ten lines on the dial are cut approximately equal distances apart and parallel to this first groove.

In dividing off the main divisions on the dial:

The ruler is lined up with the first division at the left end of the scale.

The brass index plate is moved along the upper radius of the board until the index on the ruler snaps into the left groove of the index plate.

The ruler is next moved to the second point on the dial and the index pin on the ruler adjusted to fall into the last groove of the index plate.

With the index on the ruler in this position, the ruler is returned to the first point on the dial and the line drawn with a ruling pen against the surface of the ruler.

The ruler is then moved to the next index point and the operation repeated until all ten lines are drawn.

The general layout of this piece of equipment is shown in Fig. 1. The following paragraphs are numbered to correspond with the part numbers in this general view:

1. The board itself consists of a ½″ thick piece of Bakelite or hard plywood 10″ × 15″. The upper 15″ surface is cut on an 8″ radius to provide a surface on which the brass index plate (5) is fastened by means of spring clamps on the under side. Four small rubber feet are provided on the under surface to prevent slipping and to provide space along the upper edge under the board for the clamps of the index plate (5).

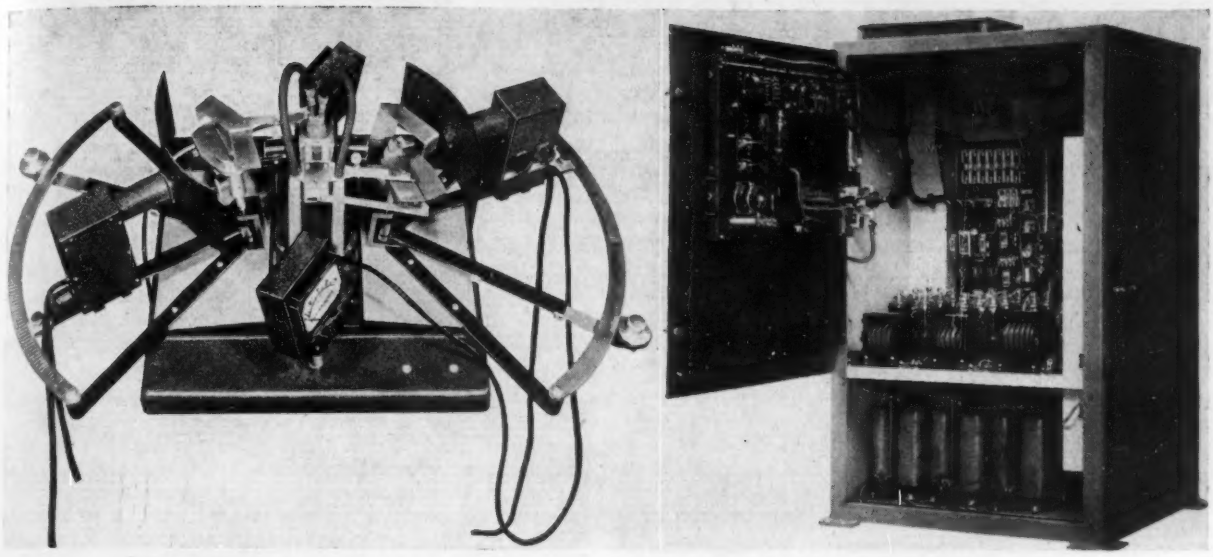
2. A Bakelite ruler with a transparent celluloid edge is pivoted in the center of the board concentric with the 8″ radius described above. It is made to fit over a pin at its pivot point in such a way that it can be easily removed in order to mount the scale to be drawn. Two 1/16″ spacers are provided at each end of the ruler to keep the surface used for drawing off the dial and the index plate.

3. Two pins are provided for holding the dial firmly in position on the board. These are arranged at approximately 0.005″ greater distance between centers than the corresponding holes on the dial. Two screws are then threaded through the Bakelite with tips slightly off-center in such a way that when the dial is placed over the pins and they are turned, the dial will be securely fastened to the board by the outward thrust of the eccentric on the screws. This method of clamping can, of course, be modified to suit individual requirements, although it is important that whatever method is used, the holes in the dial are used to guide it in position. If the edge of the dial is used to locate it on the board, some difficulty may be encountered with the small misalignments that can occur in punching the mounting holes on the dial and locating the corresponding supports on the instrument mechanism.

4. The index pin which locates in the grooves of the index plate (5) is fastened to the ruler by means of an adjustable phosphor-bronze strip. This strip is arranged in the form of a letter "J" with the hooked portion of the "J" over the right edge of the ruler and the long section provided with a hard steel needle which indexes into the grooves of the brass plate (5). It is ⅜″ wide by 0.015″ thick and adjusted to give a spring action against the grooves when the operator holds the ruler against the dial to draw the line. A small screw is soldered to an upper surface as a knob to facilitate sliding along the ruler.

5. A 3″ square brass index plate approximately 0.020″ thick is held fast by two ½″ wide phosphor-bronze clamps which project over the upper edge and hold the plate to the board (1). These two clamps are arranged to give a good fit and still allow for sliding the brass plate along the upper radius of the board. A 1″ × ½″ × 1/16″ thick piece of brass is soldered to the upper edge of the plate as a handle to facilitate moving the plate across the radius of the board. Eleven grooves are cut in the brass plate by means of a small scriber tool. The first, or left-hand, groove is cut on the diameter and is parallel to the surface of the

(Concluded on Page 93)



Two widely different production-line instruments—an X-ray orientation unit for cutting radio quartz crystals; and an automatic roll welding controller for aircraft aluminum work—both utilizing constant-voltage transformers.

Constant-voltage Control—The New Design Essential

By C. H. HUMES, Sola Electric Company, Chicago, Illinois.

ONE of the most important prerequisites for satisfactory performance in modern electrically-operated precision equipment or electronic devices is an operating voltage stable to within narrow limits.

During the years that have followed the introduction of radio and electronics, electrical engineering design has become increasingly complex. Consequently, devices in use today often have a sensitivity and delicacy which make them unable to tolerate the voltage variations that occur on commercial power lines.

For instance, unless protected by some adequate means of assuring constant current, an electrical machine which sorts foodstuffs—or one that tests colors by the use of light—or a burglar alarm using the principle of the electric eye—could produce defective or erroneous results because of a drop or a surge in power. If such an extraneous circumstance could influence results, the work of the equipment might be completely—and rightly—discredited.

Should this occur, and the usefulness of a product of their firm be discredited, the management and the sales force would also become conscious of the importance of voltage control. It is one thing to produce and distribute a splendidly-made automatic instrument or machine, but quite another thing to have to explain why it does not function as promised. For management and for the sales force, the all-important detail about any device is its actual performance under conditions of actual use. And they are right!

Manufacturers of such devices know, from laboratory experiments, what is the ideal, the necessary, voltage for operating their products. Unfortunately, they often leave the matter there! From that point on it devolves upon the user of the product to protect his property and to utilize it at maximum efficiency.

Just how is the user to do this? Where is he to find a dependable source of voltage, stable to the degree essential in producing the results he wants and has been promised? This is where the manufacturers of precision and electronic apparatus are up against what might be termed a public relations problem. Their products are vulnerable to bad treatment, and the worst part of it is that this bad treatment will be entirely unintentional, involuntary and natural on the part of the users.

To realize the extent of the handicap under which a device may be called upon to operate, manufacturers might find it interesting to test their products, not under the controlled conditions of their production laboratories, but under the workaday circumstances where nine out of ten of the machines will actually be used. In other words, try out voltage variations on their products and study the results.

Only recently has it become generally appreciated by design engineers that voltage fluctuations on commercial and industrial power lines are, universally, far too great to be tolerated without unfavorable reaction by modern electrical equipment. It is not astonishing that this fact has only recently been recognized, because the older types of electrically-operated devices did not require close voltage control. This is not true in the case of many electrical products today. That is why many design engineers have found it advisable to treat the source of operating power as one of the essential problems in basic design. The truth of the matter is that they have learned much of value about voltage from actual experience, and from the old trial-and-error method.

In some cases, the need for voltage control has become evident only after a product has been marketed without inherent protection against fluctuations. Fortunately, it is now becoming general knowledge among engineers and manufacturers that the lack of power control is the source of many operating troubles in cases of unsatisfactory performance and expensive replacements, and adequate prevention is being provided by the use of constant-voltage transformers as a built-in part of newer machines.

The presence of voltage variations is not something to be charged up against the commercial power plants. They are in business to deliver to their customers what is really a "raw material" or a "bulk product." It would be impossible for them to control its quality at the source, for many self-apparent reasons, including the fact that the requirements of the users are necessarily varied. The proper point of control is at *or in* the equipment using the power. At this point it is possible to determine to a nicety, and to provide, the exact voltage required for efficient operation. In fact, with a constant-voltage transformer, voltage can be regulated within ±1%. This means freedom from operating troubles caused by voltage jolts, sags and surges.

Exhaustive tests of voltage stability could be conducted throughout the country. The size of the investigation bewilders the imagination: all localities; all times of day and night; all surrounding conditions of industrial and other power uses; all combinations and cross-combinations of

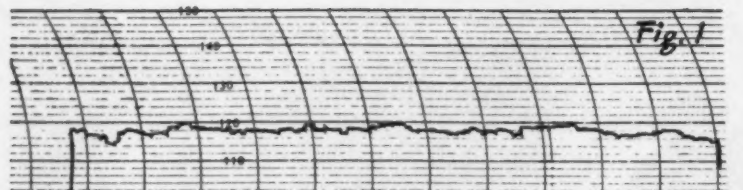
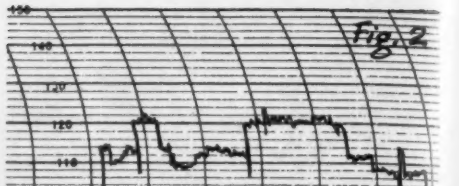


Fig. 1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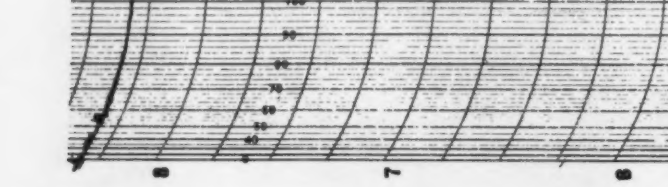


Fig. 3

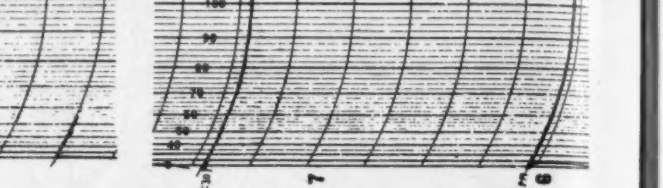


Fig. 4

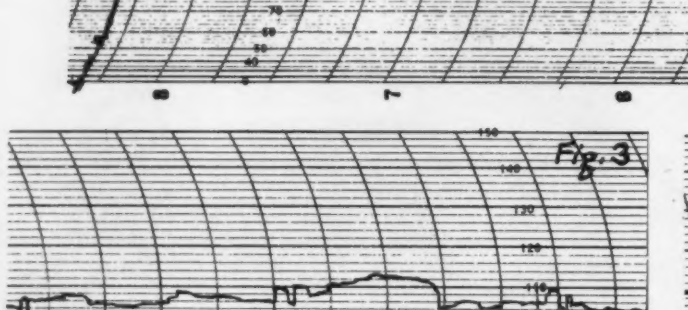


Fig. 5

Fig. 6

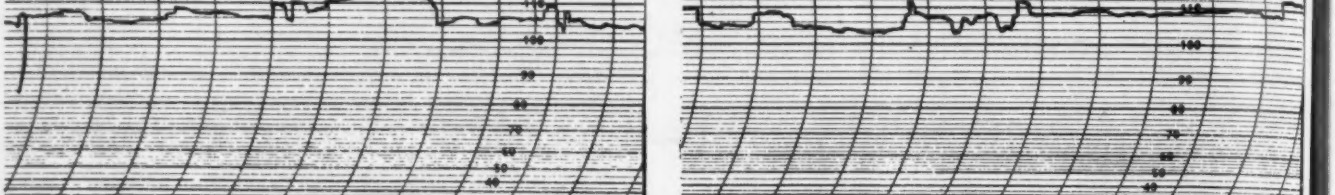


Fig. 7

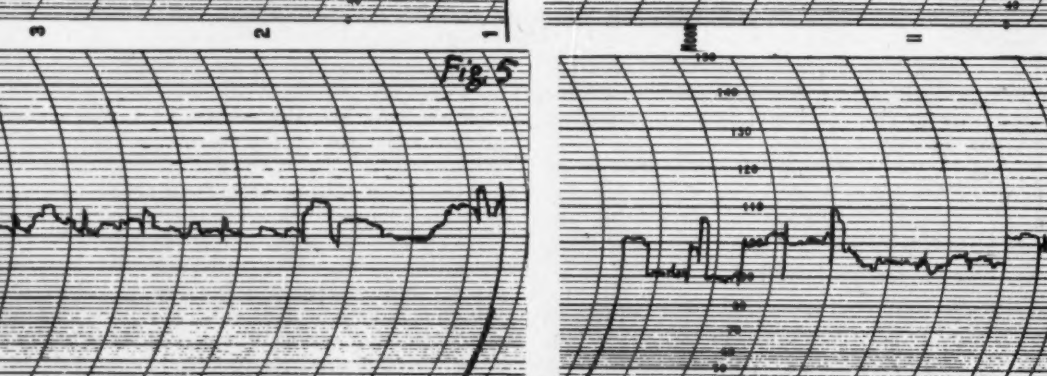


Fig. 8

these and other factors. A test made now would vary later today, however, or tomorrow or next week, and always there would be the possibility that a newly-introduced factor in any locality would radically change the results obtained.

With such an exhaustive survey it is doubtful if one would even discover a dependable pattern of irregularity! What could be proved would be that there is no voltage stability within narrow limits — and certainly not within ±1%— evidenced in any of the localities surveyed.

As a statistical procedure, such an enormous survey would be cumbersome and unnecessary. An unweighted sampling consisting of several dozen tests taken at unprejudiced random across the country would give commercially conclusive evidence of the matter.

This is exactly what was done recently by engineers of the Sola Electric Company in conjunction with the Army Air Force. They made a survey of line voltage variations existing at various points to determine the advisability of installing automatic voltage-control transformers in electrically-operated equipment being used by the Army Air Force. The places of the tests were dictated by the location of the government's operations, whether urban or rural, industrial or agricultural.

For the tests in question, safe operative voltage limits were established at 110 to 120 volts by the manufacturer of the equipment involved in the experiment. The minimum value for true precision performance was 110 volts, the maximum for safety for the equipment was 120 volts. Tests were conducted at a representative proportion of the government's 150 important installations in a certain widely inclusive territory. At each location an Esterline-Angus recording voltmeter, calibrated at each test against a laboratory standard, was installed at the site of the equipment without disturbing or altering normal operations, and allowed to record the line voltage for a period of several hours.

In more than 90% of the tests, line voltage extended beyond one or both limits over appreciable periods of time. In some the line voltage remained fairly stable during the test period, but was above or below the specification limits. In other cases, the voltage varied either beyond one, or beyond both limits. In no case were wiring systems obsolete or poorly designed.

Illustrative of conditions found during the survey is Fig. 1. These conditions proved to be the best encountered during the survey, yet the voltage here varied six volts during the test period, despite the fact that the equipment under test drew its power from a special line and distribution transformer carrying only this one load.

Average conditions found throughout the survey were much like those recorded in Figs. 2, 3, 4 and 5 which are cited as representative examples.

Figs. 6 and 7 chart extreme variations which, while not general, still are not too unusual. This is the type of situation which produces trouble for electronic devices.

Fig. 8 illustrates the fallacy of depending upon short-time or periodic voltage readings. Here the voltage remained relatively stable for extended periods, then broke into fluctuations which were violent and rapid. The result upon equipment under observation was pronounced.

Results proved conclusively that voltage control was necessary if faulty operation and possible damage were to be eliminated. In the case of these particular tests, the Army Air Force was after better operating results. The value of precision performance by their devices and instruments was counted above the protection of this apparatus or its component parts, except as the safety contributed to effective operation. Because the instruments and devices are used not only in this country but in other parts of the globe, a constant-voltage transformer was specified that could be connected for operation on either 50- or 60-cycle supply and on lines rated at 115, 208, 230 or 250 volts.

In passing, it might be noted that manufacturers or users of apparatus designed to operate at stated voltages would have been interested in what was revealed in these tests concerning protection of precision or electronic equipment from damage, replacements and expense. The possibility of materially prolonging the life of tubes is in itself of sufficient interest to justify careful inquiry into the causes of tube casualties. Primarily, however, manufacturers and users, as well as the government, are interested in performance. If a device is designed to function in a stated manner, it is important that it do so.

The government's anticipation of varying conditions on power lines in foreign countries gives a valuable hint to manufacturers who are designing precision electrical and electronic products for post-war export. Many of these devices will undoubtedly go into countries where conditions on the power lines vary as much from ours as do the climates and the populations. Without built-in voltage control they will have less chance of success; with built-in automatic voltage control, they will deliver the same performance abroad as at home.

Built-in constant-voltage control has proved of immeasurable advantage wherever used. Innumerable instances could be given, but a few definite examples will suffice.

The Photelometer is a portable photoelectric instrument which determines the concentration of substances in solution by the proportional transmission of incident light. Because this light must be of unvarying intensity, a small constant-voltage transformer is built into the unit. The accuracy of the results obtained with this device and the quickness and ease with which it can be operated have made it outstandingly popular. It is widely employed in biochemical, industrial and hospital laboratories. Its findings are used as a basis for diagnoses and in routine commercial tests. It requires a voltage that does not vary more than ±1%.

Several of the leading X-ray apparatus manufacturers are now incorporating constant-voltage transformers in the control units of their X-ray machines. They have found that an unvarying flow of power helps to eliminate distortion and fogginess in X-ray films; that it eliminated bothersome details in the operation and control of the machine by the technician; that it gives protection to technician and patient from X-ray burns caused by unexpected ray intensity; that it protects the equipment itself from damage or destruction caused by unguarded surges of voltages. The exactness made possible in X-ray work by the control of the supply voltage, and hence of the ray intensity, has opened up new fields for its use. For example, X-rays are now used in making quartz crystals for radio use. In this work the exact synchronization of the working parts is guaranteed by the even flow of power.

At the great military and civilian airports of the country the instrument landing systems are under the automatic protection of constant-voltage transformers. No matter how irregular the power flow from commercial lines may become, the signals remain unaffected. As a matter of fact, aeronautic engineers were among the first to recognize the advantage of automatic voltage control.

In burglar alarm systems, using the electric-eye principle of interrupted light, a false signal could be caused by a voltage sag. The light source which conveys the ray to the electric eye must, therefore, receive controlled voltage. The largest manufacturer of this type of burglar and sabotage protection has solved the problem by making a constant-voltage transformer a part of each control eenter.

The plywood industry is another field where constant voltage makes processes practical. The glue lines, supplying the presses in which lamination of boards in plywood is effected, are operated by high-frequency heating kept at exact temperatures by the use of controlled electric power.

Constant-voltage transformers are also part of magnetic analysis equipment with which it is possible to determine internal mechanical defects and internal flaws, as well as structural qualities, in steel. Aluminum alloy spot welding, particularly in the aircraft industry, has attained high wartime efficiency because of built-in voltage control.

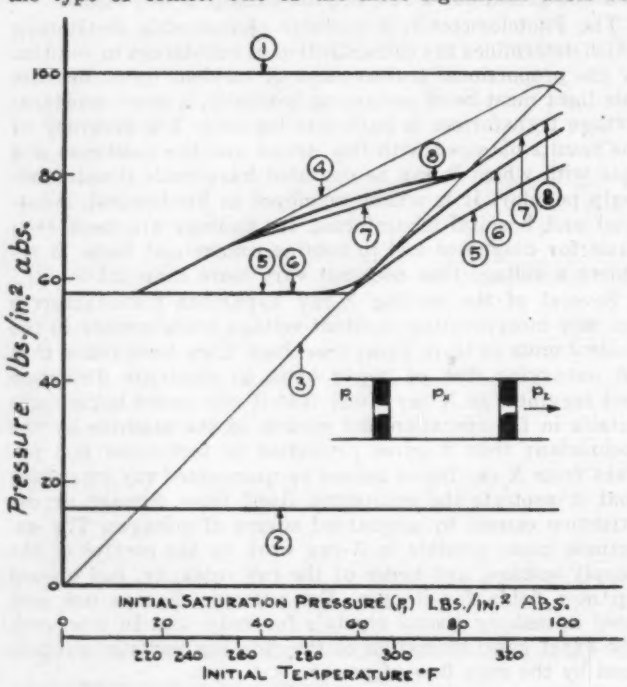
Were there still any question in the minds of electrical engineers as to the advisability and wisdom of forestalling trouble by guarding the source of power, a study of the satisfactory results reported by the manufacturers already using built-in voltage control would remove them.

Fluid Flow Through Two Orifices in Series

By MILTON C. STUART, Prof. Mech. Eng., Lehigh Univ., Bethlehem, Pa.
and D. ROBERT YARNALL, Yarnall-Waring Co., Philadelphia, Pa.

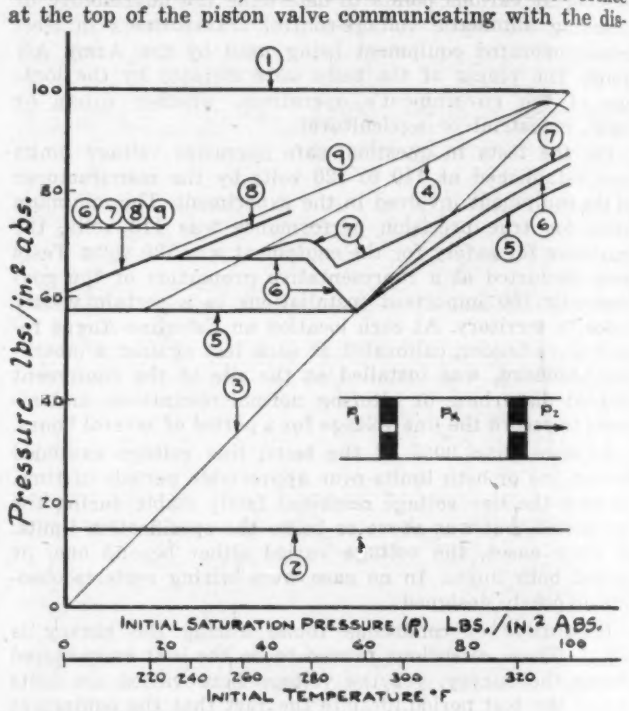
SECOND of a series of A.S.M.E. papers on the characteristics of fluid flow through two orifices in series. The first (1936) presented a theoretical analysis of the flow of water and steam through two orifices in series over a wide range of pressures and temperatures. This paper presents the results of experimental investigations on this subject using water at an initial pressure of 100 lbs./in.^{2} abs. over a range of temperatures from room to saturation temperature. The principal data sought were the pressures established in the intermediate chamber between the two orifices, and especially the variations of this intermediate pressure with reference to the temperature of water supplied and the type of orifice. One of the most significant facts revealed by these researches is that under certain conditions of flow the fluid assumes a metastable state which greatly influences the characteristics of the process. "Stable" refers to the condition in which the pressure of the liquid, or of the mixture of liquid and vapor, is not less than the saturation pressure corresponding to the existing temperature, or, conversely, that the temperature of the liquid or the mixture is never higher than the saturation temperature corresponding to the existing pressure. If a condition exists where the pressure of a liquid, or of a liquid-and-vapor mixture, is less than the saturation pressure corresponding to the existing temperature, the condition is said to be "metastable." The existence of the metastable state was demonstrated by study of a jet flow at different temperatures. The effect of the sharp-and rounded-edged orifices and the results obtained are given in Figs. 10 and 11.

These results suggest a design of an automatic control element for condensate drainage shown in Fig. 12. Such an element would consist of an arrangement of two orifices in series, in which the state of the fluid supplied causes variations in pressure between the two orifices, these pressures being in turn communicated to a pressure-sensitive member. The piston valve, which constitutes the only moving part, fulfills the combined requirements of the series-control orifices, pressure-sensitive element and drainage valve. The annular clearance between the disk on the piston valve and the wall of the cylinder forms the first orifice, the space in the cylinder above the disk constitutes the intermediate chamber, and a small rounded-entrance orifice at the top of the piston valve communicating with the dis-



1 Constant initial total pressure
2 Constant discharge-region pressure
3 Initial saturation pressure
4 Stable flow intermediate pressure
5 Metastable flow intermediate pressure for sharp-edged orifices
6 Metastable flow intermediate pressure for rounded-entrance orifices, 1 diam long
7 Metastable flow intermediate pressure for rounded-entrance orifices, 5 diam long
8 Metastable flow intermediate pressure for rounded-entrance orifices, 8 diam long

Fig. 10. Pressure Diagram for Flow of Hot Water Through Rounded-entrance Orifices in Series.



1 Constant initial total pressure
2 Constant discharge-region pressure
3 Initial saturation pressure
4 Intermediate pressure for thin-plate orifices, stable state
5 Intermediate pressure for thin-plate orifices, metastable state
6 Intermediate pressure for short tube 1 diam long, metastable state
7 Intermediate pressure for short tube 4 diam long, metastable state
8 Intermediate pressure for short tube 8 diam long, metastable state
9 Intermediate pressure for short tube 1 diam long and over, stable state

Fig. 11. Pressure Diagram for Flow of Hot Water Through Short Tubes in Series.

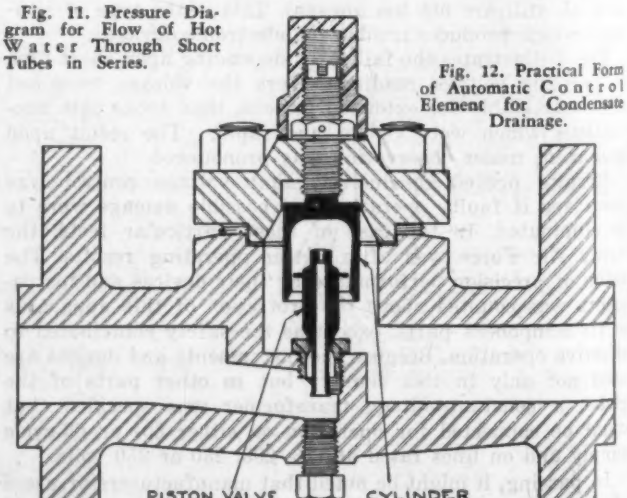


Fig. 12. Practical Form of Automatic Control Element for Condensate Drainage.

EXTENDED ABSTRACT of paper presented at Annual Meeting of A.S.M.E., New York, Nov. 28-Dec. 3, 1943, under auspices of Power Division.

charge through the center of the valve constitutes the second orifice. In order to obtain the required area relationship between the two orifices, the cylinder wall is tapered and the cylinder is made vertically adjustable to permit variation of the clearance between disk and cylinder wall. On proper adjustment, the relatively high intermediate pressure acting on the upper surface of the piston for steam and very hot condensate flow is sufficient to close the valve. With cooler condensate the correspondingly lower intermediate pressure permits the valve to lift and discharge the condensate. The device is operative in like manner over a wide range of initial pressures without further adjustment.

Desired characteristics for the variation of the intermediate pressure with initial temperature may be obtained by suitable choice of types of orifices and by relative sizes of the orifices. Further, the existence of the metastable state makes it possible to obtain a far wider range of control conditions than would be possible if the fluid remained in the stable state throughout the process.

Measurement of Damping of Engineering Materials During Flexural Vibrations at Elevated Temperatures

By CARL SCHABTACH and R. O. FEHR, General Electric Co., Schenectady, N. Y.

NEW method and new equipment developed and used by the authors for measuring the damping of materials are described. A tuning-fork specimen is set into vibration by jerking a spreader from the gap between the ends of the tines. The damping is expressed in terms of the logarithmic decrement of the decaying vibration, which is measured and recorded by means of a magnetic oscillograph, amplifiers, and a resistance-type electric strain gage cemented to the specimen. Fig. 1 shows the specimen with the strain gage and the electrical circuit is shown in Fig. 2. The solid portion of the fork is screwed to the lower end of a ⅜" diam. stainless-steel rod, whose upper end is gripped in a collet fastened to a rigid framework. The spreader is screwed to the upper end of a trip rod which is positioned by guide bushings in two horizontal plates of the framework so that its axis coincides with the axis of the rod supporting the fork. The trip rod passes through a hole in the center of a 5-lb. weight guided parallel with the trip rod. By striking a shoulder on the bottom of the

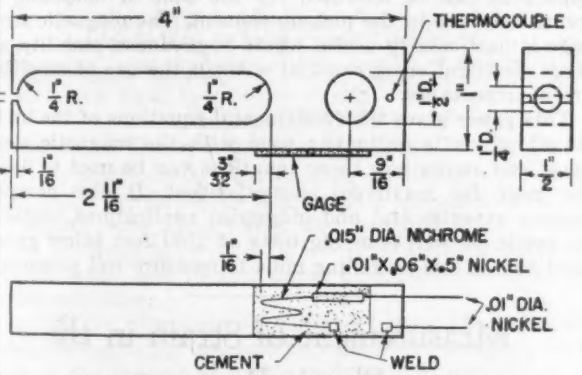


Fig. 1. Tuning-fork Specimen with Strain Gage.

trip rod, the weight jerks the spreader from between the fork tines, and the specimen vibrates with an amplitude approx. equal to the deflection caused by the spreader.

The fork and its supporting rod are enclosed by a furnace 3" diam. by 16" long inside, with a removable cover at the bottom. The spreader and trip rod are inserted through a small hole in the cover. During test, the bottom of the fork is opposite a sight hole in the side of the furnace, so that insertion of the spreader between the tines of the specimen, employing an offset spreading tool, can be viewed.

The furnace is heated electrically with a.c. through a nichrome winding around the quartz tube forming the inner wall. The temperature variation in the section occupied by the test specimen does not exceed 2% of the test temperature, in °F., and most of this occurs in the section near the free ends of the tines which contributes little to the damping.

The temperature is measured with a chromel-alumel thermocouple inserted in a 1/16" hole in the specimen, Fig. 1. Leads are brought out through the top of the furnace.

Since the furnace winding is inductive, and the damping capacity of magnetic materials is influenced by magnetic fields, the current must be shut off and the specimen demagnetized before taking the vibration decrement. This is accomplished by slowly reducing to zero the current through the furnace winding, using a potentiometer arrangement of resistance boxes.

Lead wires to the strain gage are connected to the 0.010" nickel leads on the fork at a terminal block clamped to the support rod just above the fork. Simple pressure-contact

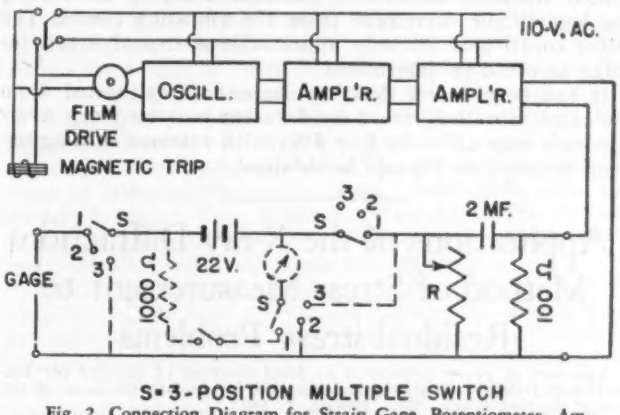


Fig. 2. Connection Diagram for Strain Gage, Potentiometer, Amplifiers and Oscillograph; with Details of Potentiometer Circuit.

connections are satisfactory, but the screw threads must be lubricated with a high-temperature bolting compound. One of the terminals is grounded, the other is carried by an asbestos insulating strip.

The gap between the little feet on the free ends of the tines of the tuning-fork specimen, Fig. 1, is made only large enough so that it will not close when the fork is vibrating. This is important for, with a large gap, slight misalignment of the spreader as it is jerked out will cause it to break contact with one tine before the other, with the result that some of the energy stored in the fork is imparted to the spreader and trip rod, and the two tines tend to begin vibrating with unequal amplitudes.

No extraordinary precautions need be taken to make the frequencies of the two tines the same.

The resistance-type electric strain gage operates on the change in resistance of a wire with strain. The authors have developed a technique of using such gages suitable for measuring dynamic strains at high temperatures. They consist of 0.0015" nichrome gage wire cemented to the specimen with Sauereisen no. 31 cement:

The fluctuating resistance of the gage wire, accompanying vibration of the specimen, is converted to an alternating voltage at the output of the potentiometer circuit, the essential elements of which are shown in full lines in Fig. 2. The dashed lines define an auxiliary circuit used for adjust-

EXTENDED ABSTRACT of paper presented at Annual Meeting, New York, Nov. 28-Dec. 3, 1943, of A.S.M.E., under auspices of Applied Mechanics Division.

ing the resistance R to equal the gage resistance and checking the battery voltage.

The output of the potentiometer circuit is supplied through two amplifiers (standard equipment) to the oscillograph. Records are made on Kodak No. 120 Verichrome film, using a standard continuous-drive film holder.

Gages constructed and located as described have about 50 ohms resistance and a nominal sensitivity factor of about 0.6, that is, the fractional change in resistance is about 0.6 of the strain which would be produced by a uniform stress equal to the nominal maximum bending stress. Hence, a nominal maximum bending stress of 30,000 lbs./in.^{2}, in a specimen of material having a 30,000,000-lb. modulus of elasticity, produces a change in resistance of $0.6 \times 0.0001 \times 50$ or 0.003 ohm in the gage wire.

At 1000 cps. frequency, the corresponding alternating voltage across the output resistor of the potentiometer circuit is about 2 mv. (rms). This is amplified to produce full-scale deflection (50 mm.) of the oscillograph galvanometer.

The transient response of the measuring circuit to the impulse occurring when the vibration starts is such that an approx. true record is obtained after about 1/1000 sec. or 1 cycle, from the start of the vibration. The impulse results from the abrupt change in the average gage resistance at the instant of release. The first ½ cycle recorded is about 25% too high, but this is not objectionable unless the damping is extremely high, i.e., 5% logarithmic decrement or above.

The equipment was investigated in detail for sources of error in the measured values of damping. Errors may arise from energy losses outside the specimen, non-linearity between the actual specimen vibration amplitude and the recorded vibration amplitude, and inaccuracy in calculating the logarithmic decrement from the vibration record. The latter constitutes the only appreciable source of error, insofar as could be determined.

It has been found that log decrements calculated from the same vibration record by different persons using average care may differ by 6 or 8%; with extreme care agreement within 2 or 3% can be obtained.

Applications of the X-ray Diffraction Method of Stress Measurement to Residual-stress Problems

Abstract of paper presented at joint meeting of Society for Experimental Stress Analysis and Applied Mechanics Division of the A.S.M.E., New York, Nov. 28-Dec. 3, 1943.

By J. T. NORTON and D. ROSENTHAL
Massachusetts Institute of Technology, Cambridge, Mass.

The non-destructive feature of the X-ray diffraction technique of stress measurements makes it ideally suitable for dealing with problems of residual stresses, especially when the residual stresses are produced by local plastic deformation. A few examples of this application are described, with its future possibilities.

(1) Production of residual stress by local heating.

A biaxial state of stress has been found on the surface of a flat steel bar heated locally above some 1100°F., with high tension in both longitudinal and transverse directions at the center of the heated spot. This pattern simulates to some degree conditions which probably prevail in actual weldments. But the variation of stress in the direction of thickness cannot be overlooked when dealing with thick welded plates. A method of attacking this problem by a joint use of the X-ray method and mechanical gages has been worked out at this laboratory similar to that devised for cold drawn tubing. Experimental verification of this method is under way.

(2) Production of residual stress by local overstressing.

Residual compression has been revealed by means of X-rays on the surface of specimens of mild steel loaded in uniform tension above the yield point. This is consistent with the view that surface of metals possesses higher strain energy than their interior. But the same effect would be produced by surface conditions such as scratches, notches, etc. This opens a new field for the investigation of the notch effect, especially important in fatigue.

(3) Production of residual stress by surface treatment (machining, grinding, polishing, etc.).

Surface treatments involve generally local heating and overstressing, which are in conflict insofar as the sign of residual stress is concerned. Although the distortion of grains caused by surface treatment lowered the precision of the X-ray method, it was possible to make a distinction between two methods of treatments, one of which produced beneficial residual compression and the other, detrimental residual tension. This offers a new means of controlling surface treatments of metals.

But the converse problem of stress relieving also can be investigated by means of X-rays. Thus, it has been found that stress relieving by over-stressing would follow in a quite general way the pattern set up by the "strain energy" criterion. Whether the stress relieving by heat treatment also would follow the relaxation time—stress relation found in creep is not yet certain, but the main features of this relaxation have been observed.

Design and Applications of a Magnetic Strain Gage

Abstract of paper presented at joint meeting of Society for Experimental Stress Analysis and Applied Mechanics Division of the A.S.M.E., New York, Nov. 28-Dec. 3, 1943.

By B. F. LANGER
Westinghouse Research Laboratories, East Pittsburgh, Pa.

The magnetic strain gage is a device for measuring small displacements. It is useful both as a research tool and as a device for the measurement and control of industrial processes. Other types of electric gages such as those which operate on changes in resistance have received considerable publicity lately and are particularly useful in cases where considerable complication in the auxiliary apparatus can be tolerated for the sake of obtaining extreme lightness in the pick-up element. The magnetic strain gage is particularly useful where ruggedness, stability, and large electrical energy output without the use of amplifiers are of importance.

This paper gives the fundamental equations of the bridge circuit which is ordinarily used with the magnetic strain gage, and shows how these equations can be used to design the gage for maximum energy output. It also describes various experimental and industrial applications, including its use in oil well pumping tests at 3500 feet below ground level and its use on rolling mills to measure roll pressure.

Measurement of Strain in the Plastic Range

Abstract of paper presented at joint meeting of Society for Experimental Stress Analysis and Applied Mechanics Division of the A.S.M.E., New York, Nov. 28-Dec. 3, 1943.

By G. A. BREWER
Ford Motor Company, Ann Arbor, Mich.

In the past a number of investigators have used grid patterns inscribed on the surface of metallic specimens to reveal the nature and extent of the plastic deformation occurring under load. For the most part the grids used have been obtained by scribing lines on the surface of the metal blank or bar. The use of scribed grids is necessarily limited by the labor and expense of this system which increases with the accuracy of the grid. The Photo-Grid process provides a photographic grid on the surface of the metal that can be duplicated rapidly and accurately on any number of specimens. The grids are deposited on the surface of the metal as exact duplicates of the master negative and as a consequence the accuracy of the deposited grid is a direct function of the accuracy of the master negative. The photogrids possess sufficient abrasion resistance to withstand severe forming operations and have been useful in deter-

aining strains resulting from forming certain deep drawn aircraft parts.

Using fine photogrids (100 lines per inch), the elongation at the point of failure in the standard tensile coupon has been investigated and found, in the case of 24ST Alclad, to be vitally influenced by grain size. At the same time this value of local elongation or reduction in area has been found to correlate closely with the ability of the metal to withstand over a 2" gage length does not at all correlate with the material's ability to bend over a sharp radius.

Photogrids printed on aircraft stampings have revealed strains of several hundred per cent existing in these parts after the forming operation without failure. Tensile tests of the parent material indicated a maximum strain at failure in a 2" gage length of only 18%. The effect of combined stress on the ultimate ductility of certain materials is most favorable and the studies of this phenomenon on metal stampings closely correlates with studies made on rocks under combined normal stresses where high plastic deformations were obtained without fatigue.

The photogrid may possibly be used to investigate elastic strain distribution in models made of low-modulus plastics. The grid can be printed on the surface of the sheet from which the model is later cut. If the combination of grid accuracy and high elastic strain is sufficient to permit quantitative measurement, the stress at the same point may be readily obtained by simple multiplication.

The photogrid may prove useful as a tool to investigate stresses in the region of notches or holes. A fine grid printed on a metal specimen at a notch will reveal the amount of strain in this area at failure. Using high-speed light sources, it may even be possible to record photographically the strain distribution at the notch just before failure under impact.

Strain Figures in Plates Under Static and Impact Loads as Obtained by the Brittle Lacquer Method

Abstract of paper presented at joint meeting of Society for Experimental Stress Analysis and Applied Mechanics Division of the A.S.M.E., New York, Nov. 28-Dec. 3, 1943.

By M. HETÉNYI
Westinghouse Research Laboratories, East Pittsburgh, Pa.

Square plates under various edge conditions were coated with brittle lacquers and subjected to concentrated static and impact loads respectively. The resulting crack patterns in the coatings show that there is a striking difference between static and impact stress distribution even at low impact velocities.

Besides the discussion of the above tests the paper also includes some firing test results, tests of the cracking sensitivity of the lacquer at high speeds of deformation and an investigation of the behaviour of brittle coatings under bi-axial stresses.

Experiments on Combined Stresses

Abstract of paper presented at joint meeting of Society for Experimental Stress Analysis and Applied Mechanics Division of the A.S.M.E., New York, Nov. 28-Dec. 3, 1943.

By J. MARIN
Pennsylvania State College, State College, Pa.

This paper outlines the various kinds of experiments that have been made to determine the behavior of materials subjected to combined stresses. The main purpose of such experiments is the evaluation of the yield or ultimate strengths of materials subjected to a combined state of stress. A discussion is given of the different types of specimens used and the test procedures required for combined stress experiments. Static, fatigue and creep loading conditions are considered, thereby covering the major kinds of loading. Methods of interpretation of the test results are also reviewed. The various problems requiring further investigation are outlined and new kinds of experiments in this important field of investigation are suggested.

Application of Electric Strain Gages to Aircraft Design Problems

Abstract of paper presented at joint meeting of Society for Experimental Stress Analysis and Applied Mechanics Division of the A.S.M.E., New York, Nov. 28-Dec. 3, 1943.

By A. H. FLAX and M. C. WARDLE
Curtiss-Wright Corp., Buffalo, N. Y.

The problems encountered in the structural design of modern stressed-skin airplanes are such as to provide ample opportunity for the application of electric strain gages. This paper deals with the techniques and equipment which have been found useful in such applications, and which may be of general interest. Perhaps the most significant feature of the airplane structure, at least insofar as stress and strain determination is concerned, is the fact that the post-buckling strength of many components is utilized in design. As a consequence, failure in these components rarely results from exceeding the ultimate material stresses. The principal stresses therefore lose most of their significance as indices of failure. The important result to be obtained from strain measurement is the state of direct and shear stress at critical points throughout the structure. These stresses are obtained from a strain rosette with considerably less computation than the principal stresses. A rosette computer has been devised by means of which the axial stresses and shear in any desired direction may be obtained from a rosette without calculation following the test. In the elastic range test data taken consists of the three stresses desired rather than three strains from which calculations must later be made. For cases where only one of the three stresses is desired, only one reading need be taken, thus facilitating rapid testing.

Another important matter in which aeronautical practice differs from that of other branches of engineering is that even in members not composed of thin skin nor subject to early buckling (such as forged fittings, extruded beam flanges, and some castings) the member is stressed beyond the elastic limit by design loads. Thus strain measurements must be made in the plastic range. Contrary to some previously published data, it has been found that the standard Baldwin-Southwark SR-4 strain gage is dependable at the relatively high values of strain involved.

Because of the large number of gages employed in the usual structural test, a strain-indicating unit with a single bridge built in (such as some of the commercially available equipment) is unsuitable for such work. A multiple bridge unit is necessary. A remarkably compact multiple bridge input unit containing 40 bridges has been developed by the Curtiss-Wright Corporation. Two such units may usually be operated by one man in conjunction with a direct reading strain meter. In the input unit, particular attention is given to simplification of wiring and ease of identification of the wiring of each channel to avoid confusion in tests where large numbers of gages are used. The direct strain reading unit consists of a d-c. amplifier and a meter calibrated in strain units. Drift in the d-c. amplifier must be compensated periodically during the test. A later model of the unit employs an a-c. amplifier which eliminates this drift. These direct strain reading units have the advantage of speed and simplicity of operation over the generally used null type of indicator.

For quasi-static flight work, the unit employing an a-c. amplifier is used. Because of the limitation on the number of channels which may be used in flight, the rosette computer principle is of great value in flight testing. A carrier system with recording oscillograph is used in dynamic flight work.

Strain gages may be adapted to many varied uses. Southwell's method for determination of buckling loads may be extended to use measured strains rather than deflections. Load distributions on wings and tails in flight may be determined. Control forces and control surface hinge moments are readily measured. Strain gages are easily used as accelerometers and vibration pick-ups.

Additional applications of strain gages are also discussed in the paper, together with possible future adaptation.

Practical Reduction Formulas for Use on Bonded Wire Strain Gages in Two-Dimensional Stress Fields

Abstract of paper presented at joint meeting of Society for Experimental Stress Analysis and Applied Mechanics Division of the A.S.M.E., New York, Nov. 28-Dec. 3, 1943.

By R. BAUMBERGER, Ruge-deForest, Cambridge, Mass.

All resistance wire strain gages consisting of more than a single strand are sensitive to strain transverse to the axis of the gage. For this reason a single value of gage sensitivity is valid only if a certain ratio exists between the strains axial and transverse with respect to the gage axis. Such is the case with simple tension and compression specimens. But when the stress field is two dimensional some compensation must be made for transverse sensitivity when careful measurements are called for, as in the case of rosette gages.

It is the object of this paper to derive practical formulas for finding true strain from gage readings allowing for the transverse effect and expressions for the error involved when this effect is neglected. Formulas are obtained for general types of gages and for particular commercial models of the Baldwin Southwark SR-4 gage.

A general method for calculating the sensitivity of a gage from its geometry is applied to a wire of arbitrary shape in a general strain field. The special cases of a plain grid gage with semi-circular ends and a saw-toothed gage are then worked out and the formulas put in terms of width, length, and the number of strands for convenient use. Results are compared with formulas derived from the assumption that the resistance change of a gage is a linear combination of the strain along and across its axis. Both of these approaches are checked against calibration data taken on several standard SR-4 types and the verified formulas are tabulated. They give true axial strain in terms of the factor furnished with the gage, the ratio between axial and transverse strain, and the gage reading.

Strain rosettes are next considered. Formulas are obtained for true strain along the components of a general equiangular rosette and for the 45°, the 60°, and the t-delta rosettes. As an adjunct to this information, expressions are included for the principal stresses and their directions in terms of readings made with the four rosette types treated.

The above information clarifies the behavior of single gages under non-simple strain conditions and makes their use as improvised rosettes quite feasible. But stated manufacturing tolerances and normal errors in gage application and measurement must still be kept clearly in mind.

Measurement of Dynamic Stress and Strain in Tensile Test Specimens

Abstract of paper presented at joint meeting of Society for Experimental Stress Analysis and Applied Mechanics Division of the A.S.M.E., New York, Nov. 28-Dec. 3, 1943.

By R. O. FEHR, E. R. PARKER and D. J. DeMICHAEL
General Electric Co., Schenectady, N. Y.

The tensile strength and the yield strength of test samples of cold rolled steel, and of dural were measured while the specimens were being broken by a force applied at high speed in a high-velocity impact-testing machine.

The paper presents some results of these tests, contains a description of the technique and of the analysis used. The adequacy of technique and analysis is demonstrated.

Wire strain gages were used to make the stress measurements. The dimensions of the test section were not small compared to the wave-length of the applied force, and in consequence the time element was no longer negligible. In interpreting the records, use was made of the theory of longitudinal wave transmission, since commonly used laws for determination of stresses due to forces applied gradually are not valid here. The theory of longitudinal wave transmission also gave information on some of the limitations of the high-velocity impact-testing machines.

Investigation of the Cross-spring Pivo

Abstract of paper presented at joint meeting of Society for E perimental Stress Analysis and Applied Mechanics Division of t A.S.M.E., New York, Nov. 28-Dec. 3, 1943.

By W. E. YOUNG, Westinghouse Elec. & Mfg. Co.,
East Pittsburgh, Pa.

The cross-spring pivot, or elastic hinge, consists of a sy tem of flat springs intersecting as in the letter X. The en of the springs are fastened to the two members which it desired to connect. This system has the characteristic rotating approximately about the intersection of the sprin and in many applications it can advantageously replace t knife edge. The cross-spring pivot appears to have sever qualities which often make it superior to either knife edg or pin connections in controlling an oscillating motion. It perfectly elastic since there are no moving parts in conta to produce friction; also its construction enables it to wit stand a sudden reversal of load which might unseat a kni edge. Its chief advantage over a pin connection lies in t fact that with no moving parts in contact, no lubrication necessary and no wear takes place. The author develops d sign formulas for certain standard forms of the two-sprin pivot on the basis of experimental results. Formulas a developed for the spring constant, bending stress, and m tion of the pivot point. It is concluded that, except in t case of extremely accurate instrumentation, the cros spring pivot may sometimes be used for deflection angles high as 45°.

Model Analysis of Structures

Abstract of paper presented at joint meeting of Society of Ex perimental Stress Analysis and Applied Mechanics Division of th A.S.M.E., New York, Nov. 28-Dec. 3, 1943.

By C. H. NORRIS
Massachusetts Institute of Technology, Cambridge, Mass.

Methods which are used in the analysis of structura models are discussed. These methods are the ones mos commonly used in the M.I.T. Structural Analysis Labor atory. Certain of them are well-known and therefore ar discussed briefly. Other methods in use in this laborator are not as well known and therefore are presented i greater detail. These include the moment indicator an moment deformeter used in stress analysis problems an an adaptation of the sonic method for determining th frequencies and shapes of the normal modes of vibratio of structural models. In addition, a description is include of a spring balance used to compensate for the creep o certain photoelastic materials.

Surface Fatigue of Plastic Materials

Progress Report No. 16 of the A.S.M.E. Specia Research Committee on Strength of Gear Teeth

By EARLE BUCKINGHAM, Professor of Mechanical
Engineering, M.I.T., Cambridge, Mass.

Surface fatigue is a phenomenon largely responsible fo one type of wear, commonly known as pitting. To evaluat this phenomenon a special testing machine has been buil and tests have been run almost continuously during th past 6 years. This machine consists of two shafts runnin in plain bearings, one mounted in a heavy fixed frame an the other mounted in a substantial swinging frame. Th test rolls, with a maximum face width of 1" and fro 2.200" to 4.00" diam., are mounted on the shafts. A loa is set up between them by a calibrated spring acting again the swinging frame. Revolution counters are connected t each shaft. Gears may be mounted on the ends of the shaft in such a manner as to obtain any desired amount of slip ping or rubbing between the two test rolls. Many of th tests under rolling conditions are run without gears, th rolls driving each other by friction. Plain bearings wer used to avoid the possible dynamic effects of ball or roll

bearings. An oil pump provides oil for the bearings and the gears. The testing machine is driven by a small Sprague dynamometer, and records are kept of the torque input during the runs. The physical properties and the structure of the materials under test appear to have a pronounced influence on the nature of the surface failure. Many data on various steels are given.

ERRATA IN JANUARY ISSUE

P. 11, Cermak art., 10th par.: For "The acquaint" read "To acquaint."

P. 26, footnote: For "FULL TEXT" read "EXTENDED ABSTRACT."

P. 28, caption: Scale width is 10", not 11".

P. 32, 2nd col., 2nd par., 6th line: For "by" read "be."

P. 33, table: heading "SUPERVISORY OBJECTIVES" should straddle third, fourth and fifth columns—not second column.

P. 76, 3d col., 5th line: For "untilized" read "utilized."

EASILY BUILT SCALE MARKING MACHINE

(Concluded from Page 84)

means of a small scriber tool. The first, or left-hand, groove is cut on the diameter and is parallel to the surface of the ruler (2). The remaining ten grooves are cut approximately parallel to this first one in such a way that they are at successively greater angles to the ruler as they are viewed from the left to the right end of the index plate. When the index (4) is near the upper edge of the ruler, the pin fastened to it will fall in the successive grooves along a fixed radius. This will produce a series of evenly-spaced divisions on the scale. If the index (4) is moved nearer to the center or pivot point of the ruler, the divisions shown on the scale will be correspondingly farther apart, though still evenly divided. In the unit described, and primarily designed for drawing hand-stepped scales with an arc radius of 3", the distance between the lines on the index plate is approximately 1/16".

To locate the grooves on the index plate (5), mount it to the board and scribe an arc along its upper edge and another one along its lower edge. Locate the top of the end lines by setting the ruler to the shortest scale increment and marking these points on the top arc of the index plate. Next, with the index pin in the left of these two points on the top arc, slide the index plate to the beginning of the longest scale increment. Move the index pin along the ruler until it reaches the arc along the lower edge of the index plate and mark the point of intersection. Move the ruler to the other end of the longest scale increment and mark the point at which the index pin falls on the lower arc. Divide both the upper and the lower arcs between the marked points into ten equal parts. Connect the corresponding points on the upper and lower arcs with grooves described in Paragraph 5. For uniformly-divided scales such as those normally encountered on d-c. instruments, these lines will be practically parallel. On non-uniform a-c. voltmeter, ammeter or wattmeter scales, these lines will taper outward from the upper arc to the lower arc. In both cases, though, the left-hand index line will be directly on the radius or in a straight line with the ruler.

For scales with other than uniform characteristics an index plate (5) can be made with the lines close together at the left end and farther apart at the right end. The exact spacing would be determined by the inherent characteristics of the scale being drawn. For example a plate could have the current squared characteristics of a thermocouple type radio-frequency ammeter for stepping scales of this type or with slightly non-uniform characteristics of the common variety of a-c. moving-iron or electrodynamic type a-c. instruments.

INSTRUMENT SOCIETIES CALENDAR

City	Society and Secretary		Date	Place	Subject	Speaker
Atlanta	Georgia Society for Measurement & Control	Roger W. Allen, 376 Nelson St., S.W., Atlanta	Feb. 28(A)	Blue Flame Room, Atlanta Gas Light Co.	Flow Meters	M. F. Merl, Republic Flow Meters Co.
Baltimore	Baltimore Industrial Instrumentation Society	C. B. Willnecker, 6732 Danville Ave., Dundalk, Md.	Feb. 18(C)	Caribbean Tea Room, 2432 N. Charles St.	The Rotameter and Its Secrets	Kermit Fischer, Pres. Fischer & Porter Co.
			Mar. 17(D)	Maryland Academy of Sciences	Instruments in Performance Testing of Aircraft	F. C. Phillips, Glenn L. Martin Co.
Chicago	Chicago Society for Measurement & Control	Carl Hope, 2626 W. 31st Blvd., Chicago	Mar. 6(B)	M&M Club, Merchandise Mart	Furnaces with Controlled Atmospheres	N. K. Koebel, Lindberg Eng. Co.
			Apr. 3	To be announced	pH Control	Dr. W. N. Greer, Leeds & Northrup Co.
Gulf Coast	Gulf Coast Instrument Maintenance Men's Ass'n	T. H. Pierson, 3030 Roberts St., Beaumont, Tex.	Mar. 8		To be announced	
Hartford	Hartford Society for Measurement & Control	Stephen J. Zelle, Whitney Chain & Mfg. Co., Hartford, Conn.				
Newark	New Jersey Society for Measurement & Control	N. E. Chance, 14 Glen Oakes Ave., Summit, N. J.	Mar. 7(B)	Essex House, Newark	Application, installation and maintenance of flow measuring equipment	(1) George A. Martin Standard Oil Co. (2) W. J. Suber, Brown Instrument Co.
New York	New York Society for Measurement & Control	H. R. Kalbfleisch, 114-35 No. Blvd., Flushing, N. Y.	Feb. 29(B)	Building Trades Emp. Ass'n, 2 Park Ave.	Long and short wavelength measurements	Dr. R. M. Sutton, Haverford College
			Mar. 28(B)	Building Trades Emp. Ass'n, 2 Park Ave.	Electronics: Servant or Fad (with dem't'n)	Dr. P. G. Weiller, Kollsman Instrument Co.
			Apr. 25(B)	Building Trades Emp. Ass'n, 2 Park Ave.	New Optical Tools for Research	Dr. W. B. Rayton, Bausch & Lomb Optical Co.
N. Indiana	Northern Indiana Soc. Measurement & Control	R. W. Schreiner, 4 Waltham St. Calumet City, Illinois	Mar. 10(B)	Lake Hotel, Gary, Ind.	Dev. of Perm. Magnet and Applications	C. A. Maynard, Indiana Steel Products Co.
Philadelphia	Philadelphia Society for Instrumentation	J. E. Gambrill, 1317 Spruce St.	Feb. 16(B)	Engineers Club	Industrial electronic power applications	F. W. Wentker, Mgr. Electronic Applications, RCA
Pittsburgh	American Society for Measurement & Control	L. M. Sussny, c/o Carnegie Institute, 4400 Forbes St., Pgh.	Feb. 28(B)	Roosevelt Hotel	Automatic Temperature Control	C. O. Fairchild C. J. Tagliabue Mfg. Co.
			Mar. 27(B)	Roosevelt Hotel	Valve Selection for Automatic Control	J. C. Peters, Leeds & Northrup Co.
St. Louis	St. Louis Society for Instrumentation	Gus Holubeck, Union Electric Co., Venice, Ill.				
Toronto	Canadian Society for Measurement & Control	T. C. Agnew, Minneapolis-Honeywell Reg. Co., Toronto				

(A)Meeting at 7:30, no dinner. (B)Dinner at 6:30, meeting at 8. (C)Dinner at 7, meeting at 8. (D)Meeting at 8, no dinner.

News items crowded out of this issue, will appear in March

This cannot be removed

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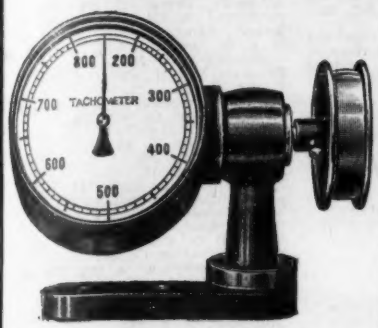

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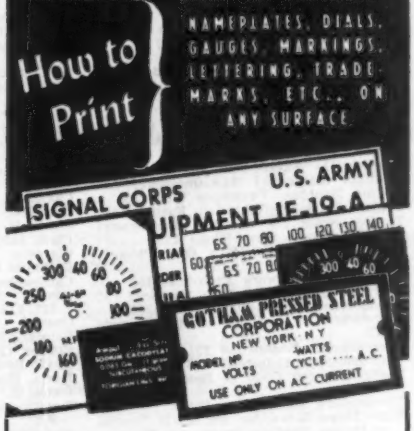

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Aviation Instruments

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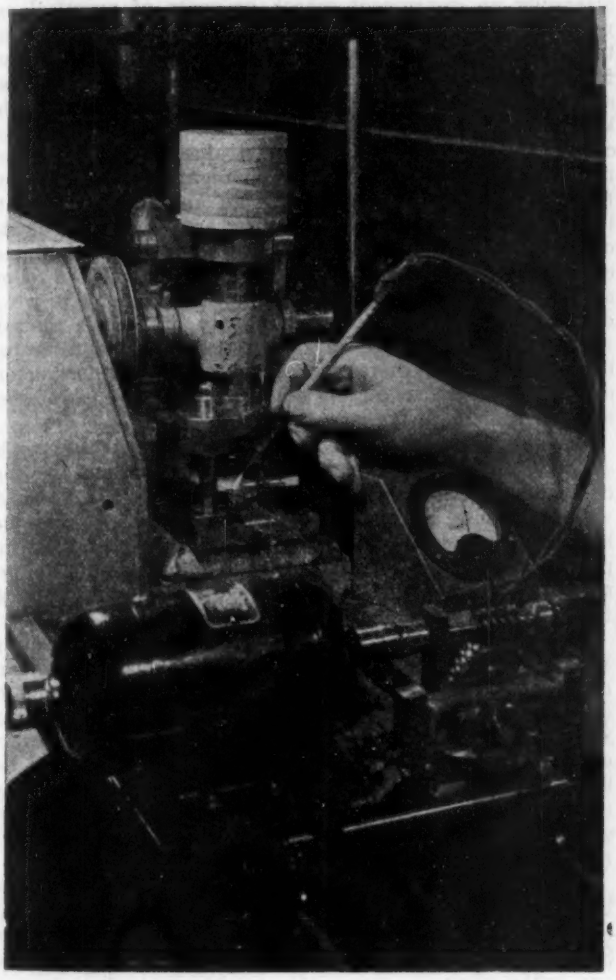

Machine Produces Glass Bearings for Airplane Instruments

ESSENTIAL part of our vast airplane program, millions of electrical instruments awaited a substitute for the tiny sapphire bearings formerly supplied from factories of Switzerland, now blockaded by the Axis. According to Westinghouse engineers, American ingenuity found a way to make these vital instrument jewel bearings of glass. At first they were made slowly, by hand, one at a time. At best, a worker could make about 1200 a day, of which many were imperfect. Now they are turned out by automatic machines at the rate of 3500 per day—and one girl can tend two machines. This glass-jewel development wiped out a threatened war-production bottleneck and—according to Westinghouse officials—produced a better product. For many types of instruments, it is said, engineers now prefer the glass bearings to those of sapphire.

ASC's Mobile Instrument Repair Shops

Owing to the general importance of this exclusive article, it does not appear in this "magazine within a magazine" but is given the place of honor in this issue. See pages 82-83. —MFB

AIRCRAFT INSTRUMENT GUILD

INTERNATIONAL HEADQUARTERS

812 N. DELAWARE PLACE
TULSA, OKLAHOMA

The following articles have been contributed by the Aircraft Instrument Guild. For further information on any of the subjects discussed, write to the Guild at the above address.

Suggested Requirements for CAA-rated Mechanics

PRELIMINARY REPORT

By R. G. OJERS, Guild President

OUR appeal to all instrument mechanics to send in their opinions as to the necessary requirements to become licensed as specialists by the Civil Aeronautics Administration has brought forth wonderful response from Guild members and non-members, but, considering the great number of mechanics reached, either directly or through *Instruments*, I'm afraid many will not be represented. If you have not yet written me, please do so after reading this report.

The following outline is both a digest of the letters received and some opinions of the writer. Please study it then submit your suggestions for additions or deletions or any changes you would want made.

The concensus follows the trend originally outlined in the November issue of *Instruments*. The ratings listed are:

S. Mechanical (Standard) Instrument Mechanic.
G. Gyroscopic Instrument Mechanic.
E. Electrical Instrument Mechanic.
O. Optical Instrument Mechanic.
M. Maintenance Instrument Mechanic.
I. Instructor Instrument Mechanic.
W. Watchmaker Instrument Mechanic.

The W rating was suggested by Albert Muller and ten other mechanics from a Dallas instrument overhaul shop. The writer agrees that the W rating should be given serious consideration. An article by the writer will appear in a future issue of this magazine, dealing with the necessity of accurate time on all transport planes. While this need is not so urgent today, in the near future when many more planes will be serving the public through cross-country or

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feeder lines, a different picture will be presented. Let's look to the future. This W rating could be an extension of the S rating.

The M rating drew considerable comment and rightly, too, as many good mechanics are in this bracket—in fact their career soon ends if they aren't good or fail to become good quick. Their work is every bit as important in their field as the other brackets, considering the importance of their knowledge in maintaining quality as well as accuracy. Their work should be controlled the same as other ratings.

The I rating has come up for least discussion. Why? Are you satisfied as is? The instrument mechanics I have contacted, with Instructor ratings, are of the opinion that it should be revised. Instructors with ratings and no other knowledge of instruments say they should not be revised. Their lament deals with the necessity of being instrument mechanics before they could teach, which would require attending an instrument school, or years of practical experience. But how many of you would allow a surgeon to perform an operation on yourself or members of your family if he had never actually cut through skin and flesh and expertly worked on the diseased organs—if all the knowledge he possessed was obtained from a book? Of course, this comparison is rather strained. There are many points to be discussed pro and con regarding requirements for this bracket. The writer would appreciate comments before outlining a too specific program. Some are of the opinion that only experienced *all-around* instrument mechanics should be allowed to teach. This is a rule we follow at the Spartan School of Aeronautics. It may prove a definite handicap to a large majority of schools that do not have facilities like ours. On the other hand, it has been proven that there are many instrument instructors doing a good job in certain subjects, who have never seen the inside of an instrument or airplane.

We are all aware of the fact that an instructor may be entirely at a loss for actual experience of overhaul, testing, calibrating or installation, but still instruct to a good advantage, while an instrument mechanic with a profound knowledge and long experience of all the above find it impossible to pass on this knowledge to students so that they may have a continuity of training, giving them a basic foundation of mechanics.

No comments have come in on the O, or optical rating. While this is definitely in the same category as standard instruments, it is the writer's opinion that it should be combined with the S rating only as an extension such as S-O. Inasmuch as many instrument shops are not called upon to do this type of work, their mechanics would not have these units available to obtain the necessary practical experience, whereas those shops that do this work should allow their mechanics to obtain an extension on their S rating.

The E, or Electrical rating should likewise be added to both the S (mechanical) rating or the G (Gyroscopic) rating, as both combine these two classes of work in many instances, creating the necessity or knowledge beyond either one or the other.

Here is a suggestion for the requirements in obtaining our ratings in all brackets: Compile a list of possibly two to four hundred questions and answers and have them accessible to everyone desiring to take the test. Questions and answers to be of such a nature that the applicant will have a fair knowledge of his work after they are learned.

The theoretical test and practical test will be given in the nearest shop complete enough to handle the procedure.

First the Civil Aeronautics Administration inspector will give the theory test to the applicant, in the presence of the instrument foreman, department head, lead-mechanic or some experienced instrument mechanics, preferably one with a rating. The inspector would choose questions at random as he wishes. These may be written or oral or both. The number of questions asked to be decided upon by the inspector, foreman or both. After this test has been passed sufficiently, a practical test will be given.

The practical test will be in the presence of the Civil Aeronautics Administration inspector or the foreman or both. Any instrument (or group of instruments) desig-

nated by the inspector, to be completely overhauled, calibrated and tested by the applicant, after which it will be run through the various required manufacture tests, then disassembled to determine the quality of workmanship as well as precision of calibration.

The E (Electrical) rating test should be given similarly by having the applicant answer any number of questions to be given from a long list previously publicized. The practical test should cover methods of testing circuits for shorts, opens, grounds, leaks, or bad connections by testing for resistance, loads, scale readings, volts generated, etc.

The O (Optical) rating test: Similar but given only in a shop that has available facilities and units to be worked on. In other words, it is a waste of effort to obtain a rating of any kind if it is not to be used sufficiently to keep the mechanic in practice.

The M (Maintenance Mechanic) test could follow the same trend as the other brackets as far as the answering of questions and, for the practical test, assign projects for the applicant to perform, such as finding and eliminating "trouble" created by the inspector—in the Pitot static installation, in the fuel air ratio installation, the vacuum installation, etc. Another project could be the construction of a sub-panel for the compass and compensating. In fact, there are many different projects that could be given to verify the applicant's competence.

I would like to suggest to Mr. O. E. Patton, Instrument Unit, Aircraft Engineering Division, Civil Aeronautics Administration (who has charge of setting up the program of licensing instrument mechanics) to call in three or four men with long experience for a conference to be held in a centrally located city to discuss these various ratings and to help him outline the requirements for ratings, that they may be most advantageous to all concerned—the instrument mechanics and operators (airlines, schools and private owners), with safety and dependability the outstanding consideration in all decisions.

In obtaining a renewal of your rating or ratings, the only requirements necessary should be a letter signed by your foreman certifying that you have performed work covered by your rating or ratings in the last six months prior to your application for renewal. If you have been out of instrument work for six months or more prior to application for renewal, the complete examination would be taken. If a man is discharged from his position for carelessness or any reason that may create a doubt in the minds of the C.A.A. Inspectors, he would appear before an examining board to explain why his ratings should not be cancelled.

Do not be alarmed by the strictness of this proposed program, as the instrument mechanic without a rating will not be hurt in the least. A rating should be an incentive to gain additional knowledge, skill and experience in this trade that is of such importance to the aeronautical industry.

Many mechanics that are employed as specialists such as bearing and pivot reconditioners, calibrators, inspectors, etc., may feel that a program such as this may interfere with their position. *The lack of a rating will not be grounds for discharge.* Surely, not for some years. A rating will be mainly for the safety of the aeronautical industry and an incentive for the mechanic to strive for more knowledge that his ability may be recognized.

More confidence will be created among airplane operators when they know a certified Civil Aeronautics Administration approved mechanic will either actually do the work or supervise, inspect and okay the work performed on their instruments. How many of you would be willing to take an airplane "ride" with a pilot that does not have his required license? While this license does not necessarily make him a good flyer or pilot, his having a license proves that he had to meet certain requirements in order to obtain one. This holds true for the certified instruments mechanic.

It will be to the benefit of your foreman and employer to have as many rated mechanics in your instrument shop as possible; you may depend upon his coöperation.

Again let me ask for your comments. Generally speaking, does this meet with your approval? If not, send in your suggested changes, so that the complete résumé may be sent to Mr. Patton for his consideration.

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Fuel Mixture Indicators

By SIMON S. JACKEL, Instructor, Aircraft Instruments, Army Air Forces, Eastern Technical Training Command, Yale University, New Haven, Conn.

(Continued)

PART III—INSTALLATION

The *Analysis Cell* is mounted on suitable brackets adjacent to the engine. In single-engine airplanes this is usually on the engine side of the firewall (not on the cabin side because a possible gas leak would be dangerous there). In multi-engine airplanes the analysis cell is mounted at some suitable place in the nacelle. In any event, the cell location should be such that the filter temperature does not exceed 52°C. (125°F.), and such that neither the cell nor the sample line be exposed to freezing temperatures (to prevent condensate from forming ice and thus stopping the line). In case of extreme heat the cell may be cooled by a blast tube, and in case of extreme cold, the filter chamber and waste line may require partial insulation. To insure good drainage of condensate from the cell, it should be so positioned that the inlet pipe points directly upward. The manufacturer recommends that rubber shock mounts be used; it is this writer's opinion, however, that rigid mounting via a steel mounting plate may be used and will give satisfactory results.

The *Gas Sampling System.* The Inconel sampling nipples are placed in the exhaust stack (tail pipe), or in the collector ring if a stack installation is not possible. Figs. 5, 6, and 7 show preferred installations.

The exhaust stack (tail pipe) installation is preferred since a composite sample from all cylinders at uniform pressure is obtained. Where there is an insufficient length of tail pipe to accommodate the sampling nipples, the collector ring installation will have to be used. Where a ring installation is used, care must be exercised, for the effect of centrifugal force and injector action may cause negative pressure or reverse flow in certain sections of the ring.

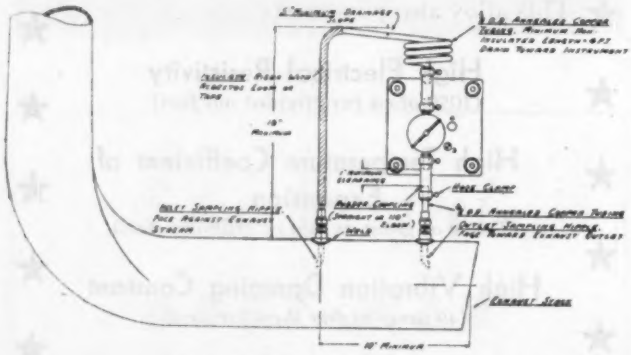


Fig. 5. Exhaust Stack Installation.
(NOTE—Figs. 5-11 incl. courtesy Cambridge Instrument Co.)

The nipples are screwed into the threaded flanges which are welded to the tail pipe or ring, the inlet nipple being turned upstream and the outlet nipple downstream. If the tail pipe is sufficiently long, the inlet nipple should be placed at least 12" from the outlet of the pipe, for a nipple located too close to the end of the tail pipe may receive gas diluted by outside air, especially at low engine speeds. An inlet nipple located in the collector ring should be so placed as to receive a gas sample under positive pressure from the greatest possible number of cylinders. An outlet nipple in the same installation should be placed where the greatest suction is obtained. In the event of an overhead stack or ring the installation of the exhaust nipple will have to be changed since the condensate cannot be discharged from a rising waste line. In such a case, an extension tube may be rigged up to carry the exhaust gas to a point outside the cowling. The outlet tip should be cut at an angle to provide suction and should be protected against freezing temperatures. If there is any doubt as to whether the sample flow is satisfactory, the pressure drop across the analysis cell may be checked and should be between ¼" and 4" of water.

Good drainage of condensate from the gas sampling system is essential to a satisfactory flow of gas through the cell. It is necessary therefore to keep the gas at a temperature above the dew point in any sections of the line where the gas flows upward in order to prevent the line from becoming water-locked and stopping the gas flow. To this end, the upward leg of the line should be not more than 18" in length, and well insulated with asbestos loom or tape. On the other hand, to assure the desired water-saturated gas sample in the cell, it is necessary to have not less than four feet of bare tubing between the highest point in the line and the inlet of the cell for cooling purposes. This section of the line may take the form of a coil, but there should be no low spots in the coil that could form water traps.

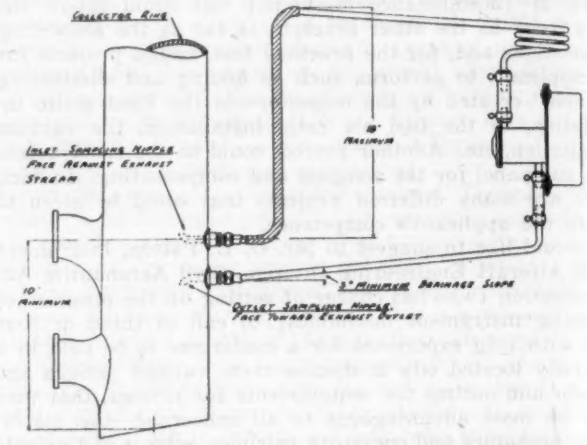

COLLECTOR RING
INLET SAMPLING NIPPLE FACE AGAINST EXHAUST STREAM
10" MINIMUM
18" MAXIMUM
5° MINIMUM DRAINAGE SLOPE
OUTLET SAMPLING NIPPLE FACE TOWARD EXHAUST OUTLET

Fig. 6. Collector Ring Installation Exhausting Underneath.

The *Indicator Unit*, Figs. 3 and 4, should be mounted on a shock-mounted instrument panel. The dial should be vertical and the scale in normal position for reading.

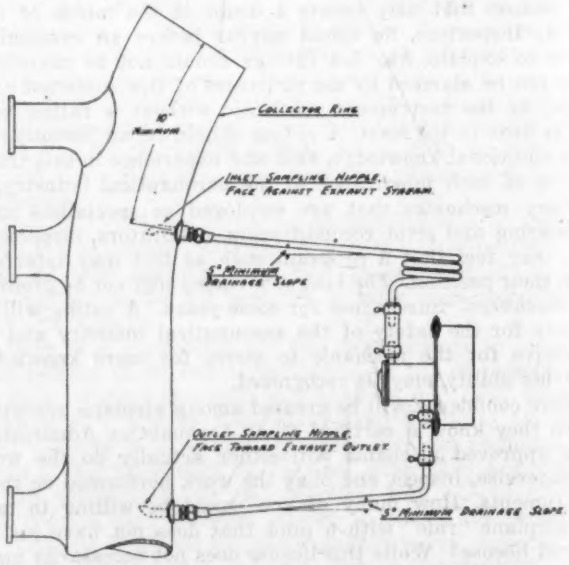

10" MINIMUM
COLLECTOR RING
INLET SAMPLING NIPPLE FACE AGAINST EXHAUST STREAM
5° MINIMUM DRAINAGE SLOPE
OUTLET SAMPLING NIPPLE FACE TOWARD EXHAUST OUTLET
5° MINIMUM DRAINAGE SLOPE

Fig. 7. Collector Ring Installation Exhausting Overhead.

The *Electrical Connections* should be made in accordance with Figs. 8, 9, and 10, for single- or multi-engine installations. Extreme care should be exercised in this, and connections should be thoroughly checked before turning on the current.

After completion of the installation, the mechanical and electrical zeros are to be adjusted according to directions in Part V, Inspection and Maintenance.

Part IV—Precautions in Use

After the foregoing instructions have been carried out, the instrument is ready for use and with the engine running will correctly indicate the fuel air ratio. The instrument will normally show responses to a change in mixture in about 30 seconds, and elapse of this time should be allowed before taking a reading.

The current should be left on continuously when the plane's engine is operating. If this precaution is not observed, carbon may form on the platinum spirals and change the resistance of the Wheatstone bridge.

The instrument may be relied upon for accuracy with mixtures leaned out to a maximum of 0.068 fuel-air ratio. When leaning out, should the pointer, in approximately this range, reverse and move back towards the "A" point,

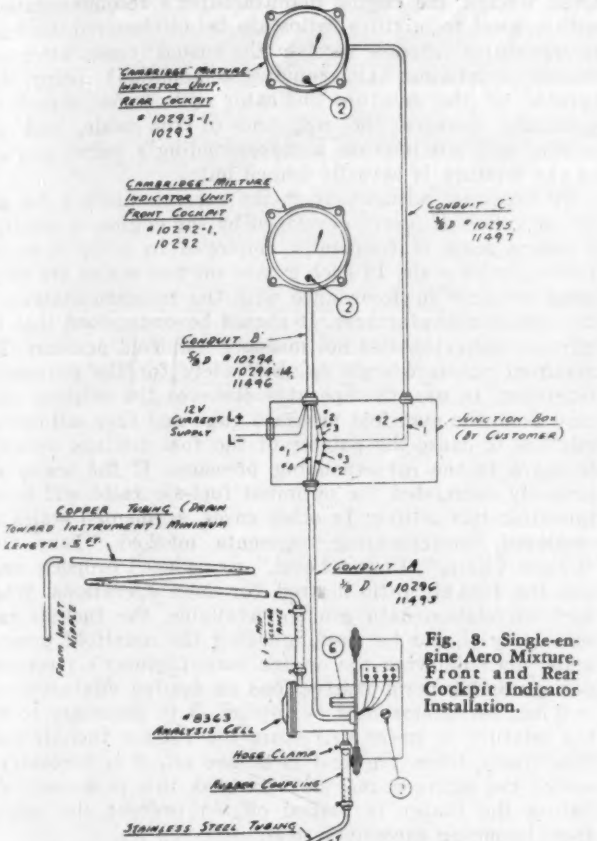


Fig. 8. Single-engine Aero Mixture, Front and Rear Cockpit Indicator Installation.

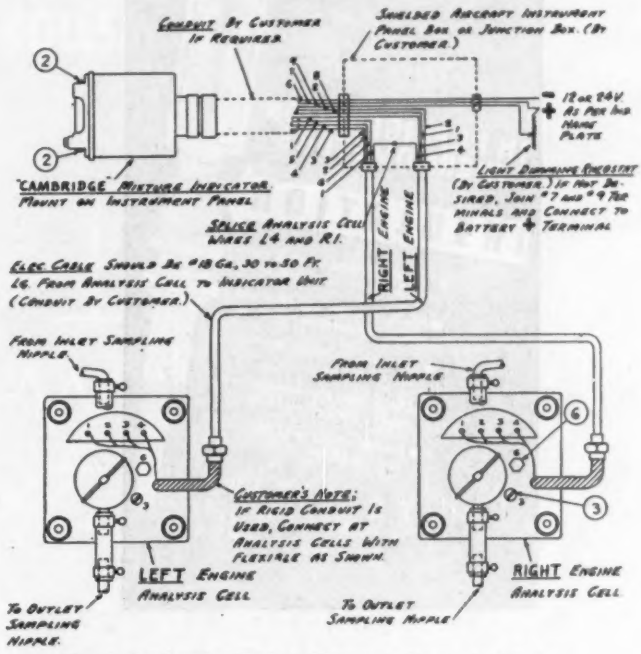

Conduit By Customer If Required
Shielded Aircraft Instrument Panel Box or Junction Box. (By Customer)
12 or 24V As Per Ind. Name Plate
Cambridge Mixture Indicator Mount on Instrument Panel
Splice Analysis Cell Wires L4 and R1
Right Engine
Left Engine
Elec Cable Should Be #18 Ga., 30 to 50 Ft. Lg. From Analysis Cell to Indicator Unit (Conduit By Customer)
From Inlet Sampling Nipple
Customer's Note: If Rigid Conduit Is Used, Connect at Analysis Cells With Flexible As Shown.
Left Engine Analysis Cell
Right Engine Analysis Cell
To Outlet Sampling Nipple

Fig. 9. Dual-engine Fuel-air Mixture Indicator Installation.

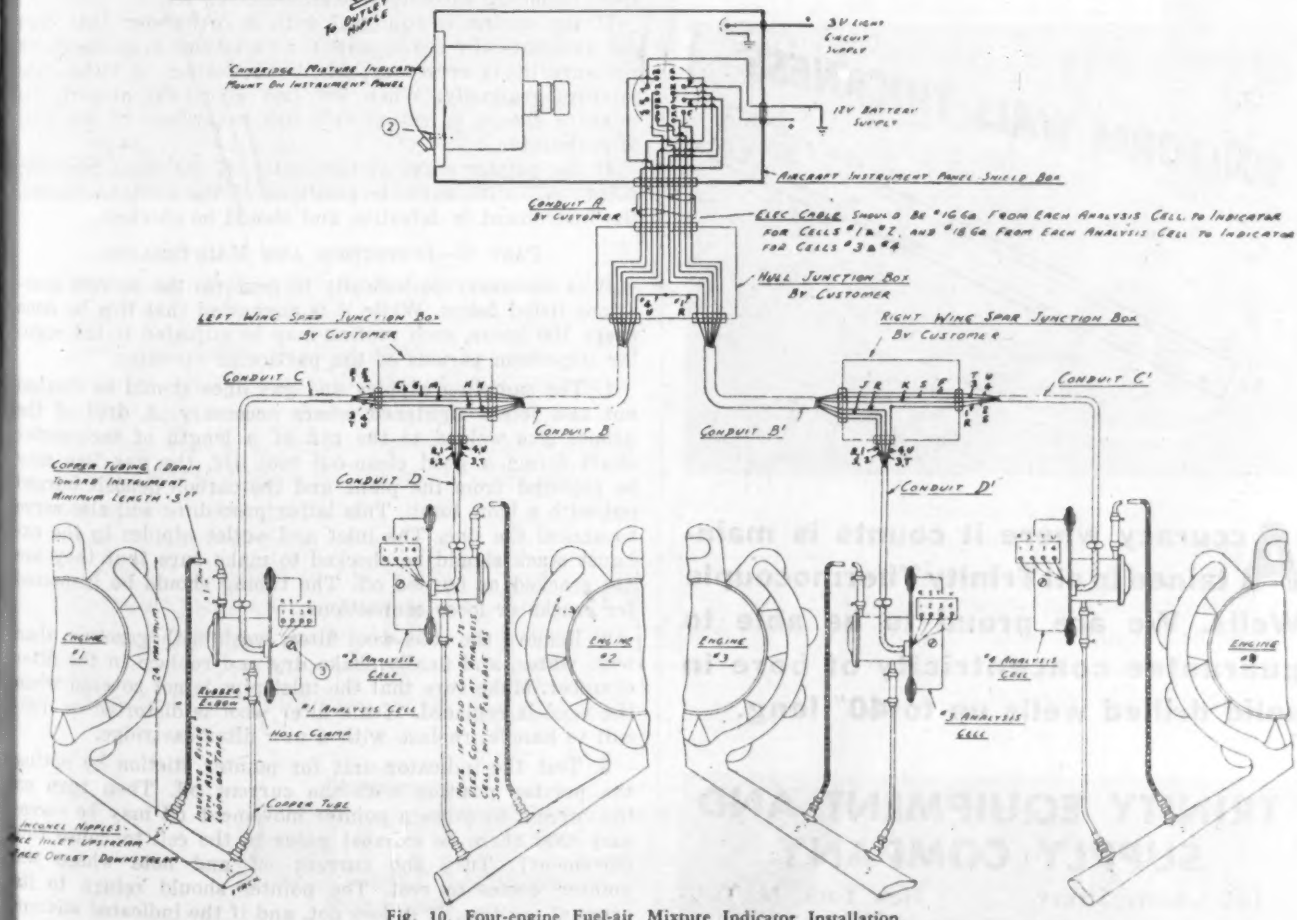
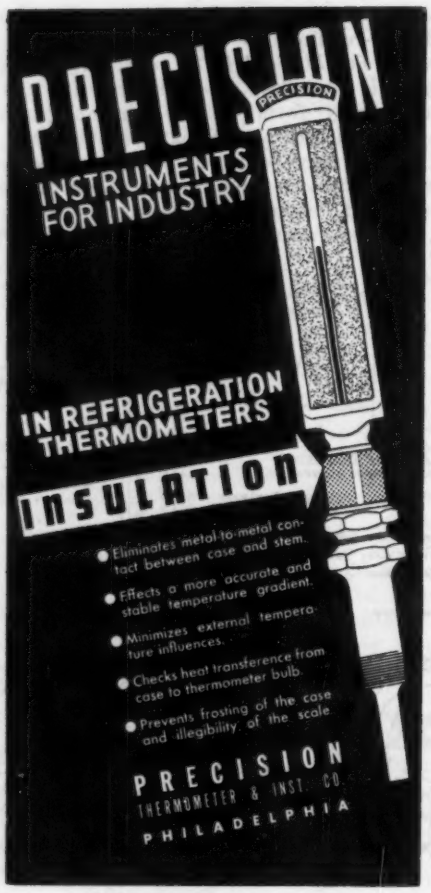


Fig. 10. Four-engine Fuel-air Mixture Indicator Installation.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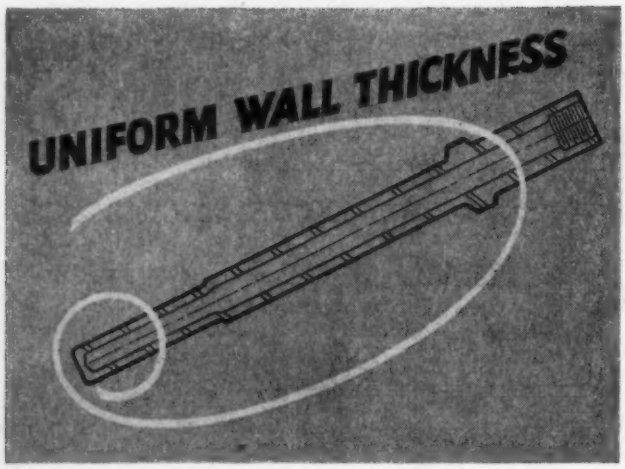

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it is an indication that the mixture is lean beyond the range of the instrument, and should be made richer.

A correct fuel-air ratio indication should not be taken as lessening the importance of the cylinder head temperature indicator in guarding against overheating the engine. Even though the engine manufacturer's recommendations with respect to mixture ratios are being observed, the head temperatures should receive the usual close attention. Should detonation (incomplete combustion) occur, the pointer of the mixture indicator will move erratically generally towards the rich end of the scale, and the pointer will not indicate a correspondingly leaner mixture as the mixture is actually leaned out.

To facilitate adjustment to the correct mixture for different values of power developed by the engine, a manifold pressure scale is frequently employed in addition to the fuel-air ratio scale. In such a case the two scales are correlated properly in accordance with the recommendations of the engine manufacturer. It should be understood that the mixture indicator does not measure manifold pressure. The manifold pressure scale is used solely for the purpose of reference. In use, the operator observes the existing pressure from the manifold pressure gage and then adjusts the mixture to cause the pointer of the fuel mixture indicator to move to the corresponding pressure. If the scales are properly correlated the optimum fuel-air ratio will be obtained at this setting. In other cases, segmented scales are employed, incorporating segments marked "Take Off," "Cruise Climb," "Cruise Level," etc., placed properly opposite the fuel-air ratio desired for such operations. Where such correlation data are not available, the fuel-air ratio scale only should be used, ignoring the manifold pressure scale, and following the engine manufacturer's recommendations and general instructions on desired mixtures.

When carburetor heat is applied, it is necessary to lean the mixture in order to restore the former fuel-air ratio. Conversely, when the heat is turned off, it is necessary to enrich the mixture, making sure that this is accomplished before the heater is turned off, to prevent the mixture from becoming excessively lean.

If the engine is equipped with a carburetor that does not automatically compensate for variations in atmospheric pressure, it is necessary, when descending, to richen the mixture gradually. When 500 feet above the airport, the mixture should be set at full rich regardless of the type of carburetor.

If the pointer stays at the center of the scale, near the point "A," with variable positions of the mixture control, the instrument is defective and should be checked.

Part V—Inspection and Maintenance

It is necessary periodically to perform the service operations listed below. While it is suggested that this be done every 100 hours, such routine may be adjusted to the regular inspection periods of the particular operator.

1. The sampling nipples and gas lines should be cleaned out and joints tightened where necessary. A drill of the proper size welded to the end of a length of tachometer shaft forms a good clean-out tool. Or, the gas line may be removed from the plane and the carbon deposit burned out with a blow torch. This latter procedure will also serve to anneal the line. The inlet and outlet nipples in the exhaust stack should be checked to make sure that they are not cracked or burned off. The tubing should be inspected for cracks or loose connections.

2. Remove the steel-wool filter, wash with gasoline, then with water, and finally shake dry and replace in the filter chamber. Make sure that the inlet pipe is not covered when the wool is replaced. If the filter wool is distorted or difficult to handle, replace with a new filter cartridge.

3. Test the indicator unit for pointer stiction by noting the pointer position with the current off. Then turn on the current to cause a pointer movement (it may be necessary that there be exhaust gases in the cell to cause this movement). Turn the current off and note where the pointer comes to rest. The pointer should return to its original position. If it does not, and if the indicated stiction

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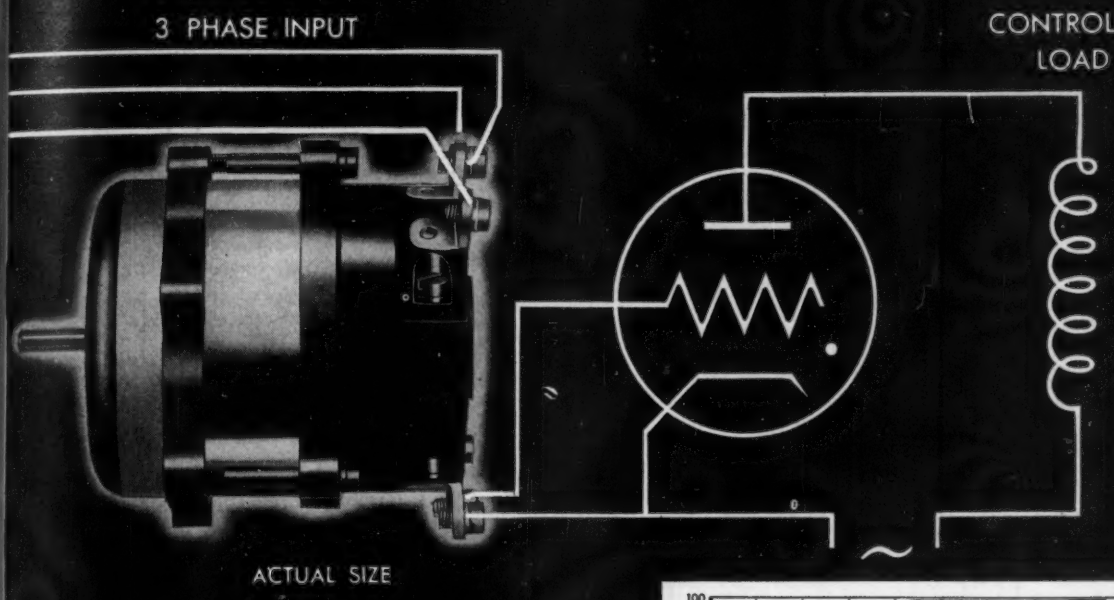

CIRCUTROL UNIT
used as
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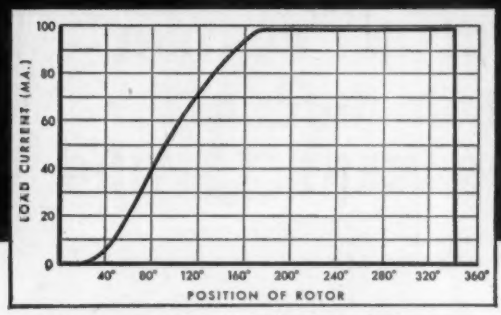

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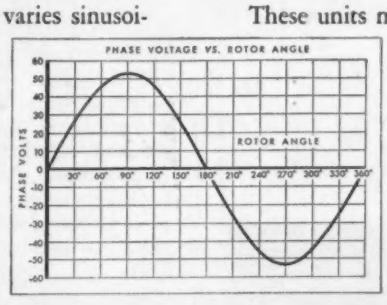

Another advantage of the unit as a rotatable transformer is that it is designed to withstand continuous rotation at speeds up to 1800 R.P.M., although many applications require nothing more than positioning of the rotor.

Electrically, the Circutrols are motor-like precision units having high impedance two- or three-phase stator windings and single-phase rotors. Units are available which operate from 32, 115 and 220 volts, 60 cycles, and 110 volts, 400 cycles.

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For complete information about the Kollsman Circutrol write to Kollsman Instrument Division of Square D Co., 80-20 45th Ave., Elmhurst, N. Y.

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is greater than 0.002 fuel-air ratio, the unit should be repaired at the earliest opportunity.

4. Wet the wick in the vapor plug (No. 6, Fig. 8 and 9), making sure that the breather hole (size 80 drill) in the plug is open, and then replace. Note that the analysis cell used on the X-IV-AS, (Fig. 10) assembly does not employ a vapor plug and wick, as the comparison spirals are sealed. Disregard maintenance instructions in connection with the vapor plug when applied to this type.

5. Mechanical Zero Adjustment. With the current off, the pointer should stand at "A" on the scale. If it does not, adjust to this position by means of the zero screw on the indicator front.

6. Electrical Zero Adjustment. The position of the pointer on the electrical zero is the same as on the mechanical zero. To check:

(a) First see that the mechanical zero is properly set.

(b) Wet the wick in the vapor plug (see Paragraph 4 above). Make sure that the pin hole in the plug is open.

(c) Remove the cover and steel wool from the filter chamber of the analysis cell, and permit to air for about ten minutes. Then place a clean wet rag (slightly wrung out) in the filter chamber in the place of the steel wool, and replace the cover.

(d) Now, with the current on, allow the instrument to stand for about 30 minutes. At the end of this time, with the current still on, the pointer should stand at "A" on the scale. If it does not, adjust to this position by means of the rheostat (No. 3, Figs. 8, 9, 10) in the analysis cell. The wetted rag should then be removed and the steel wool and cover replaced in the filter chamber. When replacing the wool, push it in sufficiently to clear the opening of the inlet pipe.

Adjustments at Major Overhaul Periods.

7. Check the current which is regulated by the ballast tube in the indicator unit and supplied to the analysis cell bridge, in the following manner: With the units connected, insert in series with the current supply lead to the analysis cell (No. 4 or "U" on the wiring diagrams) an ammeter of 0.1 ohm or less resistance, capable of measuring 180 milliamperes to an accuracy of $\pm$ 0.5%. The battery voltage should be not less than the voltage marked on the indicator name plate, nor should it exceed the marked voltage by more than one volt. The current under these conditions should be 180 milliamperes. If it is not, bring it to this value by adjusting the slide wire resistor in the indicator.

8. As indicated in paragraph 6 (d) above, a rheostat in the analysis cell is employed to balance the bridge. As the bridge electrical zero shifts at times and may reach an extent of unbalance beyond the range of the rheostat, the following treatment should be applied to restore, at least partly, the balance. Disconnect all external wires from the analysis cell and connect two No. 6 dry cells (3 volts) in series across terminals No. 1 and No. 4, or "R" and "U," and allow the current to flow through the cell for 15 to 20 seconds. Should the bridge be in balance with the rheostat in approximately the center of its travel, this treatment is unnecessary.

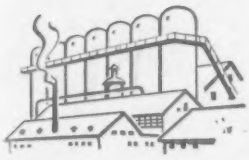
9. Anneal the copper sampling tube. This may be accomplished by removing the line from the plane and heating with a blow torch.

10. If desired, the calibration of the analysis cell may be checked. This may be done by one of two methods. First, by employing a Test Outfit, such as the Cambridge Standard Gas Test Outfit which supplies a gas of known composition: when this gas is passed through the analysis cell, a reading is obtained on the indicator unit which can be checked against the known fuel-air ratio value of the standard gas. Second, by comparing the cell under test with another instrument known to be properly calibrated and in good working order: in this method the cells are placed in series to receive the same gas sample and checks may be made at any point in the range merely by varying the gas mixture at the source of supply, which may be any gasoline engine. Should either of these tests reveal the calibration to be off, adjustment is made by means of the variable slide wire resistor (not the rheostat) in the analysis cell.

Major repairs should not be attempted unless adequate facilities are available.

(To be concluded)

MECHANICAL GUARDIANS FOR CHEMICAL PIPE-LINES



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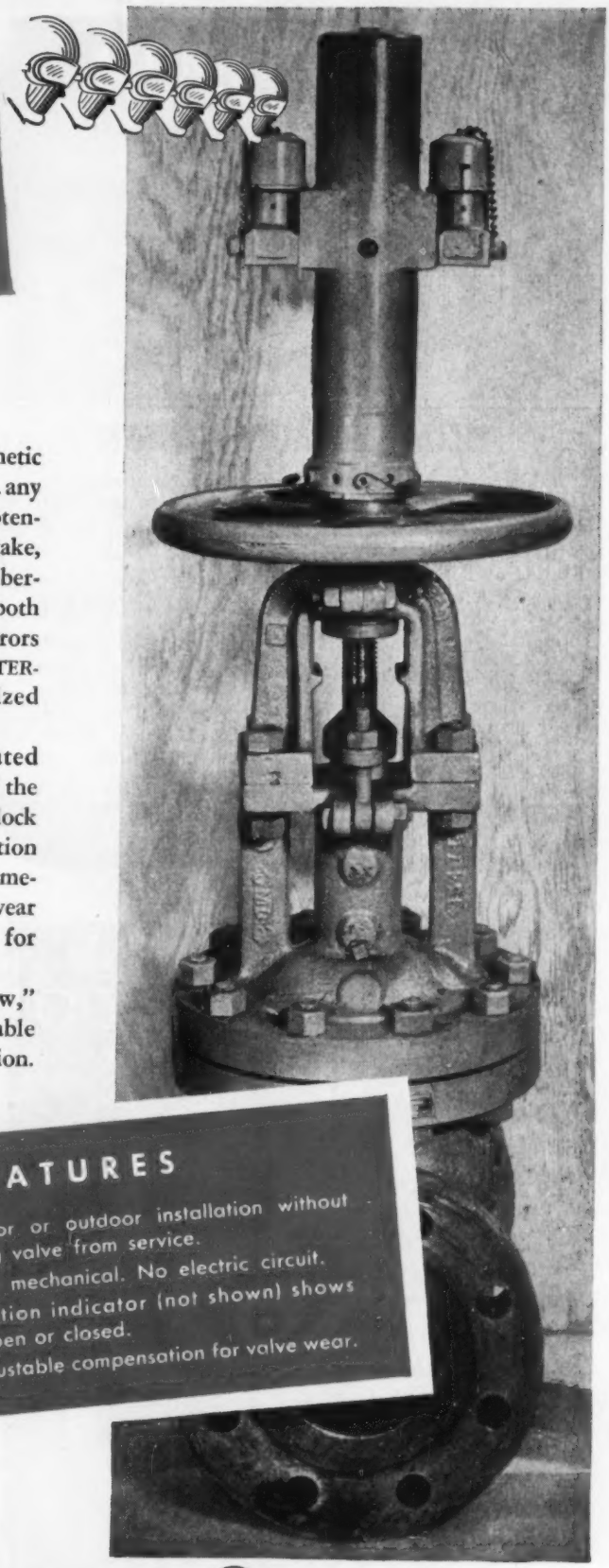
The BENDIX-CORY SAFETY INTERLOCK illustrated gives absolute control over the opening and closing of the valve to which it is attached... and, by use of an interlock key, can also control the position of this valve in relation to any number of other valves. The unit is wholly mechanical, and fully adjustable to compensate for valve wear —one of a number of interlocks specially designed for valve protection.

As safety men of the Bendix "Invisible Crew," BENDIX-CORY SAFETY INTERLOCKS are dependable guardians for your pipe-lines. Write for full information.



CHECK THESE FEATURES

- ✔ Interlocks stem valves 2" to 8". Other interlocks for globe, lead and porcelain valves.
- ✔ Absolute control of valve opening and closing under all conditions.
- ✔ Positions valve in relation to other valves.
- ✔ Ample strength characteristics.
- ✔ Indoor or outdoor installation without removing valve from service.
- ✔ Fully mechanical. No electric circuit.
- ✔ Position indicator (not shown) shows valve open or closed.
- ✔ Adjustable compensation for valve wear.

*TRADE MARK OF BENDIX AVIATION CORPORATION

Products of this division are members of "The Invisible Crew"—precision equipment which 30 Bendix plants from coast to coast are speeding to our fighting crews on world battle fronts.

THE INVISIBLE CREW
Precision Equipment by
Bendix Aviation Corporation

BENDIX MARINE DIVISION • One Hanson Place, Brooklyn, New York

DILLON DYNAMOMETERS

IN AVIATION

Used in practically every major aircraft plant for determining static thrust of propellers, loading surfaces, etc. Illustration at left shows simple tensile testing setup on pilot seat using ordinary block and tackle.

UNLIMITED APPLICATION

Dillon Dynamometers may be used in scores of mechanical setups for testing tensile strength of plastics, rope, wire, castings, wood products and many other items. Direct reading in lbs. Various capacities—low cost.

COMPACT—ACCURATE

Measures only 8¼"x6¼"x3", weighs 8 lbs. 4 oz. Not injured by overload. Has maximum hand and safety glass crystal. Immediate shipment all capacities up to 20,000 lbs.

WRITE DEPT. 80 FOR LITERATURE

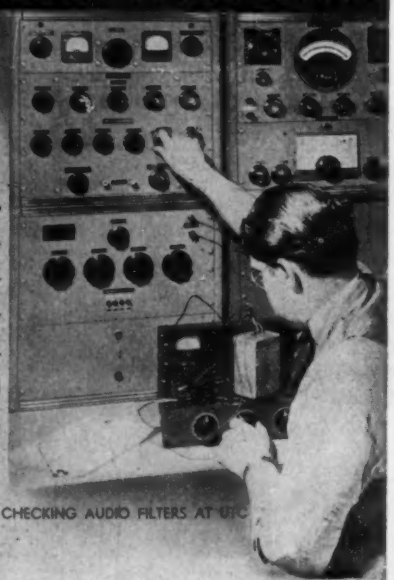
W. C. DILLON & CO., INC. 5410 W. HARRISON STREET CHICAGO, ILLINOIS

If any old transformer will do . . .

ANY MAKE WILL DO!

BUT

If your problem is • Weight, or • Size, or • Precise adjustments, or • Tougher than ordinary electrical characteristics, or • Mechanical requirements, or • Submersion type components, etc. . . .



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UTC IS THE LOGICAL SOURCE

MAY WE ASSIST YOU? A note to our Engineering Division will bring a quick response with details on units to your requirements.

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Note on Gyros that Don't Hold Calibration Overnight After Overhaul

By R. G. OJERS, Guild President

FROM various sources we learn that other instrument overhaul departments have encountered the same difficulty as our department: after overhauling a directional gyro or a pilot gyro unit and calibrating it to the specific tolerance, then checking it again after setting overnight, erratic readings in excess of allowable tolerance are found.

Our difficulties were completely eliminated by doing two things. First, using the proper amount of oil in the bearings; second, running the directional gyros on the oscillator for at least thirty minutes before starting our calibration.

Tests have proven to us that when excessive oil has been applied to the bearings, the action of the balls cause this oil to spread out, collecting all the fine particles of dirt in its vicinity and pulling them back again, after which the dirt settles to the lowest place in the race. For instance, in the bearings of the gimbal ring, the lowest place would be the ball path.

After the instrument has been operating long enough to be calibrated, quite a bit of dirt has passed through the instrument (even though filtered). Upon allowing the instrument to remain idle overnight, then checking for calibration, we find it to be erratic in readings. We correct for this by using the *minimum amount* of oil to assure us of a complete film of oil. Then, as fine particles of dirt collect on the races, they remain where they land.

The purpose of running the instrument on the oscillator for thirty minutes or more before attempting to calibrate is a form of settling and grinding-in process. It allows the bearings to become firmly sealed and set in position, checking to see if anything works loose or out of alignment. If it does, it will become apparent upon attempting to calibrate. Also, any fine particles of dirt collected in the ball path will be ground finer or larger parts pushed aside, or definitely implanting themselves in such a way that the bearing will have to be recleaned, all of which we want to find out before the instrument leaves the shop and not after.

Jaeger Tachometer Creep Tests: Testing for Freedom of Movement

By FRED E. HONEYCUTT, Aircraft Instrument Guild

WHAT does "the creeps" have to do with the Jaeger Tachometer? It is the result of friction due to drag or misalignment. At the beginning of the final test we place the tachometer on a tachometer tester which has an r.p.m. of 100. This is what should happen the instant the drive shaft of the instrument makes contact with the tester:

Power from the drive shaft is transmitted to the drive gear, from the drive gear to reverse gear, from reverse gear to commander gear, from commander gear to (let's not go up the floating pinion this time) the barrel gear, from the barrel gear to the mainspring, from the mainspring to cam arbor and escapement wheel, from (let's bypass the drag link) the cam arbor and escapement wheel to anchor pins, from anchor pins to anchor and pilot fork, from anchor and pilot fork to roller pin and split collar guard, from roller pin and split collar guard to hairspring, and here the remaining power is exhausted. Any error from the barrel gear to the hairspring will throw the movement out of beat. A perfect beat and freedom from drag has to be maintained to pass the "creep" test.

Back to the test: We have placed the tachometer on the tester but the beat hasn't as yet begun. Now the pointer is creeping around 100, 200, 300, 400. By now, enough tension has built up in the mainspring to overcome the drag, causing the movement to start and the pointer drops back to 100 r.p.m. The beat stops and the pointer is creeping around 100, 200, 300, 400. The beat begins and the

STANDARD FREQUENCIES—*Octaves of them*

FREQUENCIES

10, 20, 40, 60, 80, 100, 120, 140, 160, 180, 190

Accuracy: 10 parts in 1,000,000
Output: 30 volts at 500,000 ohms
Input: 105-125V, 50-60c., 40 watts
Weight: 50 pounds

Impossible? Well, here it is—

This Multi-frequency generator furnishes the frequencies shown above at the turn of a switch. All frequencies are obtained from a temperature-compensated tuning fork and voltage-stabilized circuit.

With this unit it is possible to calibrate oscillators at many selected points without encountering complex oscilloscope patterns. One of the uncertainties involved in development work on tuned circuits, filters, reeds—and in time measurement can be minimized with the aid of this instrument.

Developed primarily to check frequency meters for precision war work, this Multi-frequency generator possesses a rugged durability and dependability in service that will prove an extra value to many laboratories.

Additional information available on request.

Manufacturer of the Watch Master

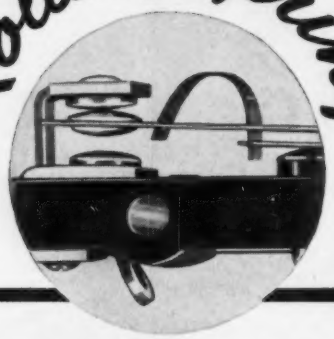
and distributor of Western Electric Watch-rate Recorders

American Time Products, INC.

580 Fifth Avenue New York 19, N. Y.

LOOK

to the Rolling Spring



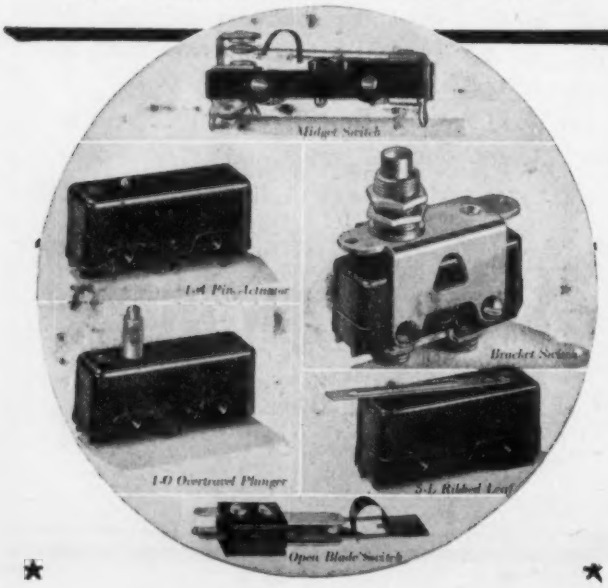
Engineered for FASTER CONTACT BREAK

You can now design your product for better Snap Action Switches.

1. **Better contact pressure is maintained until the snap-action is actually begun.**
2. **The contacts break with maximum accelerating force.**

Those two facts account for the rapidly rising preference for ACRO-SNAP Switches. The spring forces involved are engineered to compel one spring to "trigger" the other. So regardless of how slowly the actuating member is operated, the contacts break with optimum acceleration. Careful analysis also shows that good contact pressure is maintained until the snap-action suddenly takes place. These facts are borne out by laboratory tests in industry and by record breaking performance in all branches of the Armed Forces. In writing, kindly explain details of applications you contemplate.

ACRO ELECTRIC COMPANY
1324 Superior Avenue, Cleveland 14, Ohio



pointer drops back to 100. That is the way "the creeps" affects the Jaeger Tachometer.

Let us remove the instrument from the case while we point out the possible errors that would cause the pointer to creep. First, not enough freedom in bearings and pivots of the balance wheel assembly, the anchor assembly and the cam arbor assembly. Second, the roller pin and split collar guard not in alignment with anchor. Third, worn anchor pins. Fourth, burred escapement teeth. Fifth, uncentralized hairspring. Sixth, too much tension on drag link spring not permitting the cam arbor to turn with ease. There are other errors but the above-mentioned are the most frequent.

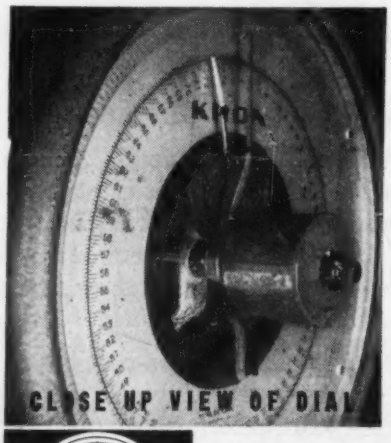
While the instrument is out of the case, we will place it again on the tachometer tester at an r.p.m. of 100. The pointer has begun to creep. We first look to ascertain if an escapement tooth has stopped against an anchor pin. We now find a tooth has stopped against the left anchor pin, which is the case nine times out of ten. This means the roller pin is too far to the left. If a tooth were to stop by the anchor pin at the right, the roller pin would be too far to the right. To shift the roller pin to the proper position, you can hold the hairspring collet with a pair of pliers and, with thumb and finger on balance wheel, turn the shaft the desired direction.

The pointer may creep just to 200 or it may creep as high as 2000 before the mainspring has built up enough power to overcome the error. The height the pointer creeps depends on the extent of error. *No creep is permissible!*

More tests for the Jaeger Tachometer will follow in this magazine.

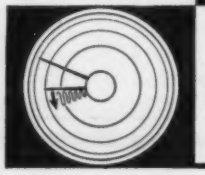
END OF AIRCRAFT INSTRUMENT GUILD SECTION

WORK! FIGHT! GIVE!
MAKE DEMOCRACY LIVE!



"Magna-Pointer" held at zero before timing interval.

"Magna-Pointer" engages and moves with weigh pointer during interval.



"Magna-Pointer" instantly stalls at end of timed interval.

KRON

Announces

ELECTRO-MAGNETIC POINTER

For Industrial DIAL SCALES and precision force INSTRUMENTS

Can be attached to the weigh pointer or detached and held stationary at any instant during a weighing operation, or force measurement without affecting the accuracy of the scale instrument.

Can be operated manually or by remote timer or switch gear.

Permits accurate "rate of flow" indication for timed intervals. It is a perfect automatic tare device for barrel, box or bag filling. It is invaluable for mixing chemicals or fluids.

KRON INDUSTRIAL DIAL SCALES

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The KRON Co.
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EVERY DAY we are shipping these precision pressure gauges to be used in place of dead weight testers. They are accurate, dependable and easy to read. Delivery—2 to 6 weeks.

RANGE FROM 0-60 lbs. to 0-10,000 lbs

12" Dial..... 144.00

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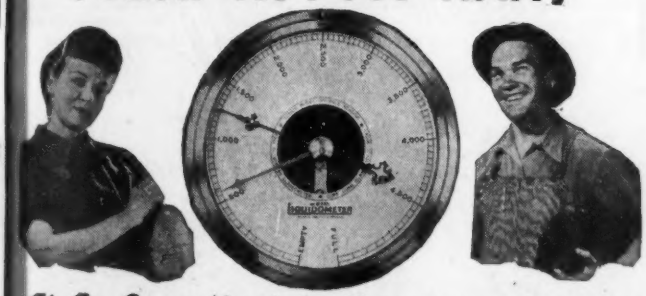

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LIQUIDOMETER *Tank Gauges*

"THEY'RE ALWAYS DEPENDABLE"

100% automatic.
No pumps, valves, or auxiliary units needed to read them.
Models available for either remote or direct readings.
Accuracy unaffected by specific gravity of tank liquid.
Approved by Underwriters' Laboratories for gauging hazardous liquids.

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● And that's no figure of speech. As an absolute matter of cold fact, millions of Aerovox paper tubular capacitors are now in daily use. They are serving in countless radio sets . . . in instruments . . . in electronic assemblies . . . in electrical appliances: day after day; year in and year out: making things last and last in keeping with the wartime economy.

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Effective Control

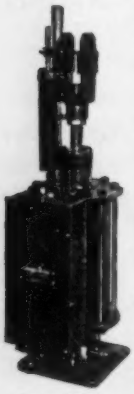
Process Control for sensitive, stable automatic control of temperature, pressure, liquid level, flow and other factors as applied to industrial processes. Responds to changes quickly, without overtravel or hunting. Ask for Bulletin No. 101.

Combustion Control that is simple but *complete* for providing economical operation of boilers of 200 h. p. and larger. Details in Bulletin No. 102.

Recorder-Controller

Boiler Meters for recording combustion conditions and guiding boiler operators. Described in Bulletin No. 44.

Multi-Pointer Gages for indicating factors such as draft, pressure, temperature and speed. These Gages are available with any number of pointers and any scale combination; in either the oil sealed bell or diaphragm construction.



Control Drive

Flow Meters for indicating, recording and integrating the flow of steam, water, sewage, air, gas and other fluids. Bulletins No. 39 and 300.

Recorders for pressure, temperature, drafts, liquid level and other factors.

C-3

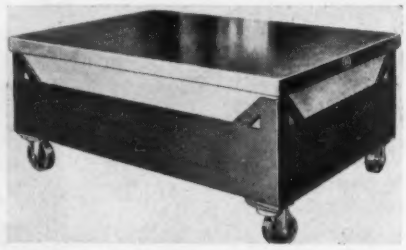
BAILEY METER COMPANY

1041 Ivanhoe Rd., Cleveland, Ohio

The Month's NEW INSTRUMENTS

2½-ton Granite Surface Plate

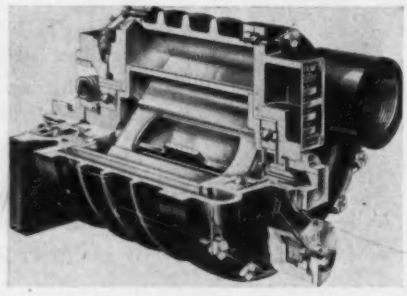
Newest addition to maker's line of surface plates (see *Instruments*, Oct. 1943, page 645) is this 5000-lb. giant, which measures 4′ × 6′. A special steel angle iron



wheel carriage facilitates ease of handling and makes the plate readily available for service in any part of the plant. Both this plate and the even larger 6′ × 8′ size may be finished to an accuracy of 0.0003″, while the standard smaller sizes are held to an accuracy of 0.0001″. Being harder than the hardest tools, as well as rust-proof and warp-proof, this huge granite surface plate is practically indestructible. *Herman Stone Co., 224 Harries Bldg., Dayton 2, Ohio.*

Aircraft Instrument Suction and Air Pressure Systems

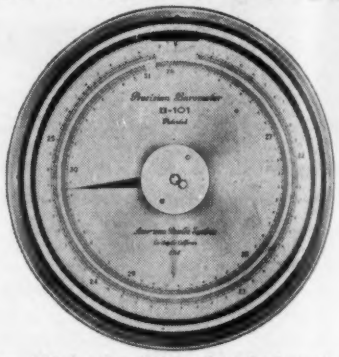
New suction and air pressure system for aircraft instruments conforms to H-1 specifications, consists of maker's "Type 764-6" engine-driven air pump, pressure safety valve, oil separator and a throttling un-



loading valve, provides 30 c.f.m. at 2,250 pump shaft r.p.m. 6″ Hg suction for gyroscopically operated flight instruments, as well as air pressure for operation of large de-icer systems. Throttling unloading valve maintains constant suction for instrument operation and unloads air pump when pressure differential between pressurized cabin atmosphere is sufficient to operate instruments. Engine-driven air pump weighing 11 lbs. incorporates overload protection, a removable flexible-drive coupling for torsional flexibility, "nitri-cast iron" pump liner and improved through type interlocking vanes. Light-weight inherently-balanced precision-machined rotor assures smooth operation at high speeds. In addition to the H-1 system, manufacturer has developed systems conforming to B-8A and B-11A specifications. Sea level ratings of the three systems are as follows: B-8A: 15 c.f.m. at 2,250 r.p.m. 4″ Hg suction, 16″ Hg pressure; B-11A: 4½ c.f.m. at 1,500 r.p.m. 4″ Hg suction, 1″ Hg pressure; H-1: 30 c.f.m. at 2,250 r.p.m. 6″ Hg suction, 16″ Hg pressure.—*Eclipse-Pioneer Div., Bendix Aviation Corp., Teterboro, N. J.*

Extreme-precision Barometer

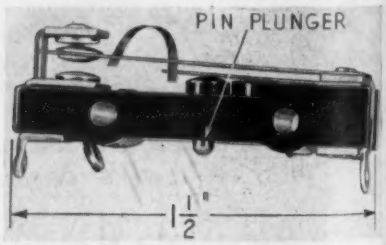
New "Barometer B-101" is latest of maker's series of null-method pressure-instruments. For initial announcement of method see *Instruments*, Vol. 1, Aug. 1928,



pages 381-2; for detailed technical discussion see *Instruments*, Vol. 4, March 1931, pages 160-162. Even early models, sixteen years ago, were sensitive to changes of altitude of two or three inches (0.000010 or 0.000015 inches of mercury). At first, accuracy did not match this extreme sensitivity. Kinematic and metallurgical developments to eliminate causes of drift, to compensate for temperature, etc., have resulted in satisfactorily stable instruments accepted as standards by scientific institutions. New "B-101" embodies these refinements while also being designed for quick readings. Dial is 10″ in diameter, range 21″ to 31″ mercury in two revolutions (scale length therefore exceeding five feet). Scale divisions are 0.01″ of mercury. Case flange diameter, 11½″; case depth 3¾″; weight 5¾ lbs.—*American Paulin System, 1847 S. Flower St., Los Angeles, Calif.*

Midget Switch

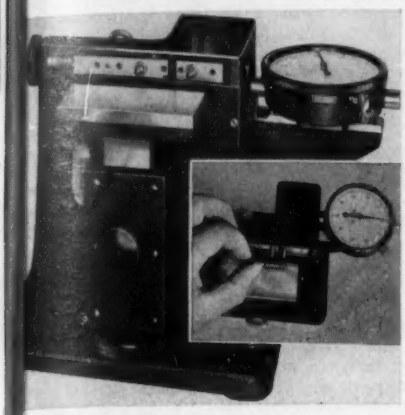
New "Acro-Snap Midget Switch" built on the rolling spring principle is 1½″ long, 9/16″ wide, 7/16″ thick, weighs less than 1 oz. All component parts are non-corrosive. Switch is designed for actuation from



either top or bottom, is applicable to electronic control devices, machine tools, aircraft and electrical appliances. It is said to be "fully approved" having stood winterization tests under Army Air Force Directive 21A, including salt spray tests and both high and low temperature tests. Both snap-action spring and center blade are made of beryllium, while the base is of Bakelite. Under factory tests the switch has shown no failure after 94 million operations. When built into relays, smaller coils may be used as only 4 to 6 oz. operating pressure is required. Furnished in single-pole normally open, normally closed, and double-throw with both pre-travel and over-travel provided.—*Acro Electric Co., 1311 Superior Ave., Cleveland 14, Ohio.*

Thread-lead Gage

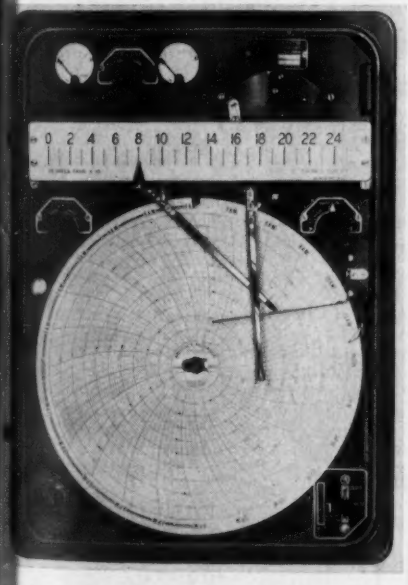
New "Model 1141" thread-lead inspection gage is adjustable both for thread lead and diameter. Sensitive contact point is free to float laterally with axis of thread and so set itself positively between sides of thread



itself. This contact is so mounted that it transfers its motion to the dial indicator through a sensitive mechanism, thus insuring accuracy of the inspection operation. Gage is set with a master. Dial indicator is graduated to read in 0.0001" and capacity of gage will take care of threads up to 1½" in diameter, a maximum distance between points of 2-11/16" and a minimum distance of 3/16". With a special attachment a minimum distance of 0.156" can be checked. — *Federal Products Corp., 1144 Eddy St., Providence 1, R. I.*

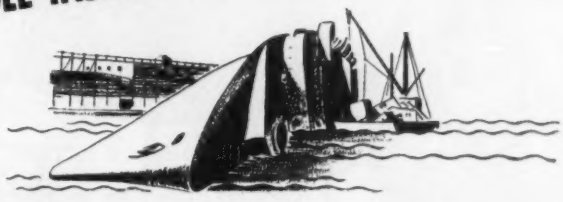
Self-balancing Potentiometer

New "Model 431 Pyromaster Self-balancing Potentiometer" has a universal wall or flush mounting case considerably deeper than previous "Model 440M," and has an internal hinged panel on which are mounted pen and indicator drive mechanism, and, in case of electric controllers, control con-



tacts or proportioning slide wire or, in case of air control, complete new convertible-type air operated control mechanism. (Detailed description of orig. "Pyromaster" with 5 figures, *Instruments*, July 1937, p. 172; numerous add'l items since.) New deep case and inner panel make it possible to service or replace any part or portion of the instrument without disturbing any other part. It also makes it possible, in the case of electric type controllers, to include the control relays in the instrument, thus eliminating considerable external wiring. A heavy-duty pen-drive motor gives more

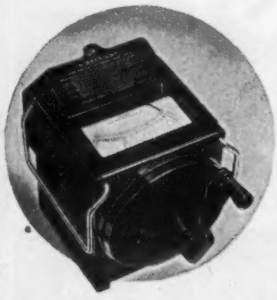
. . . by the BIDDLE INSTRUMENT REPAIR DEPARTMENT



These three "Megger" testers were on board the former liner *Normandie* when she capsized, were recovered after several months and sent to our Repair Department for whatever could be done with them. Although waterlogged and badly corroded, as shown here, we found they could still be salvaged. They were repaired, rebuilt and returned to service, practically equal to new, within three weeks' time—a tribute both to the inherent quality of "Megger" instruments and the craftsmanship of Biddle instrument makers.

For many years we have maintained an Instrument Repair Department for servicing, repairing and rebuilding "Megger" Insulation Testing Instruments, Tachometers, Frequency Meters and other specialties. Today this well-equipped and busy department is not only servicing equipment we have supplied, but also other types and makes of instruments.

Perhaps you have instruments lying idle that need only expert repairing to return them to service. If you are faced with difficulty and delay in procuring replacements, our Repair Department may be able to help you.



THE NEW . . . U. S.-MADE "MEGGER" INSULATION TESTER

in plastic molded case; with the heritage of ruggedness and accuracy common to all instruments bearing the trade mark name "Megger" . . . *Write for new descriptive Bulletin 1735-I.*

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The Permometal* tip of all PERMOPIVOTS* is your guarantee of longer life and greater accuracy for precision instruments. PERMOPIVOTS retain their satin smoothness and low coefficient of friction many times longer than ordinary pivots. They cannot corrode...require no oil...are non-magnetic.

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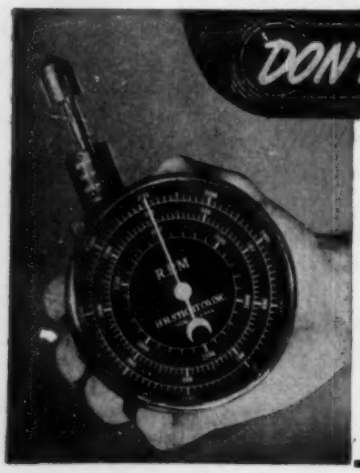


DON'T GUESS!—TEST R.P.M.

With a MODEL J

HAND TACHOMETER

Triple Range:

300— 1200 RPM

1000— 4000 RPM

3000—12000 RPM

Rugged • Reliable • Continuously Indicating Type

WRITE FOR BULLETIN #760

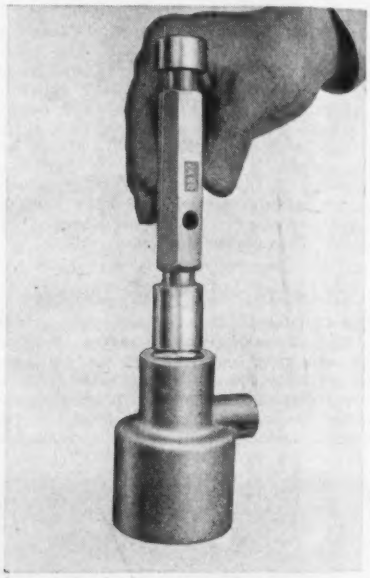
HERMAN H. STICHT CO., INC.

27 PARK PLACE NEW YORK, N.Y.

torque for operating control contacts and other similar functions, especially under conditions of poor line voltage regulation. Indicating scale on the indicating-recording model has been changed to a horizontal wide band instead of the rectangular dial type provided on "Model 440M." Stepping relays and slide wire in the potentiometer circuit have been enclosed in a dust-proof Bakelite housing, and a heavier power supply has been provided. Another change is that a standard cell type of manual standardizing circuit now replaces the voltmeter type originally supplied. New "Model 43 Pyromaster" uses the same basic principle as previous models, providing a self-balancing round-chart recording potentiometer that has no continuously moving mechanical elements, is unaffected by vibration and needs no lubrication.—*The Bristol Company, Waterbury 91, Conn.*

Piloted Cylindrical Plug Gage

New piloted cylindrical plug gage is said to be particularly adapted to gaging holes which must be held to close tolerances and also to gaging on machines where pieces to be checked cannot be removed. It lessens



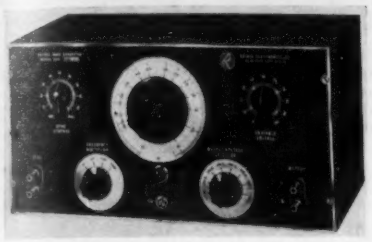
difficulty of entering a cylindrical plug gage into a bore when working to close tolerances. Ordinary plug gage is liable to jam or stick and removal of jammed gage is often a long and arduous job, sometimes leading to serious damage to gage or work. Design of piloted plug gage speeds up gage's entry into holes, even while hole is only 0.0001" over plug size, eliminates feeling or steering and is said to make it "possible for even an unskilled operator to use gage with excellent results." Reason is that pilot aligns gage with axis of hole to be gaged. It is said that new gage "will more than double the number of holes that can be gaged by an unpiloted gage." New piloted cylindrical plug gage is made in two types, one for gaging open bores and one for blind bores. —*Vard Inc., 2961 East Colorado Blvd., Pasadena 8, Calif.*

Cement for Glass Instrument Windows

Glass instrument windows have long been puttied in—like panes in a sash. It is a laborious hand operation and much time is consumed in removing the putty smears from the glass. New synthetic cement—the fruit of extensive research—seals the glass to the plastic instrument case far tighter than any putty. A simple automatic machine applies a narrow band of the cement and the glass is pressed into place. Cement sets quickly in a low-temperature oven and glass cleaning is no longer necessary. — *Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.*

Square-wave Generator

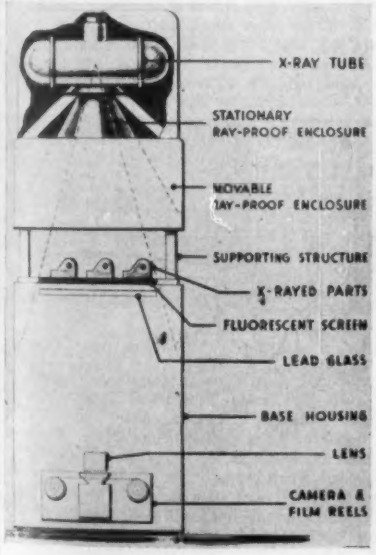
New "Model 530" Square Wave Generator is designed for production testing. It incorporates what is claimed to be "a feature not found in other square-wave generators," namely "facility of synchronization with any external frequency source."



[Provision for external synchronizing voltage is not a feature of any single make; uniqueness consists in "facility."] Instrument has a hand-calibrated frequency scale reading from below 10 cycles to more than 100 kc. Decade multiplier has four steps. Actual frequency of output is dial reading multiplied by setting of frequency multiplier. Accuracy of frequency calibration is 1% over extended periods. In cases where great accuracy of frequency is desired, instrument can be made to synchronize with any standard frequency generator, provided that a synchronizing voltage of at least 0.1 volt is available. Synchronization can also be made with any other external frequency source. Output impedances available are 100-200-500-600-1,000-2,000 ohms. Output voltage may be varied in fixed steps, or continuously by means of voltage divider. When latter is used, output impedance is from 0 to 2,000 ohms. If output voltage is varied in steps, output impedance is indicated by the output voltage selector setting. Maximum voltage output is approx. 200 volts. Power supply is designed to operate on 110-120-volts 60-cycle a.c. (It is also available for other voltages or line frequency.) Power consumption is 30 watts, fuse protection, 1 amp. Dimensions 8" × 9" × 15"; weight 18 lbs. Prompt delivery on properly certified orders. — *Reiner Electronics Co., 152-6 West 25th Street, New York City.*

Miniature-film Type Industrial X-ray Inspection Equipment

New industrial radiograph equipment fits into production line, provides photographic records "for a nickel instead of a dollar and a half," uses a high-speed camera to make 2" film negatives (instead of standard larger sizes up to 14" × 17") of any image cast upon a foot-square fluorescent



Get MORE Advantages with "COPROX" Rectifiers

- Bradley's copper oxide ("Coprox") rectifiers have high leakage resistance, combined with LOW forward resistance.
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- Even standard "Coprox" mountings are very adaptable.

"Coprox" rectifiers are supplied with presoldered lead wires, or with terminals having special provisions to prevent overheating during soldering.

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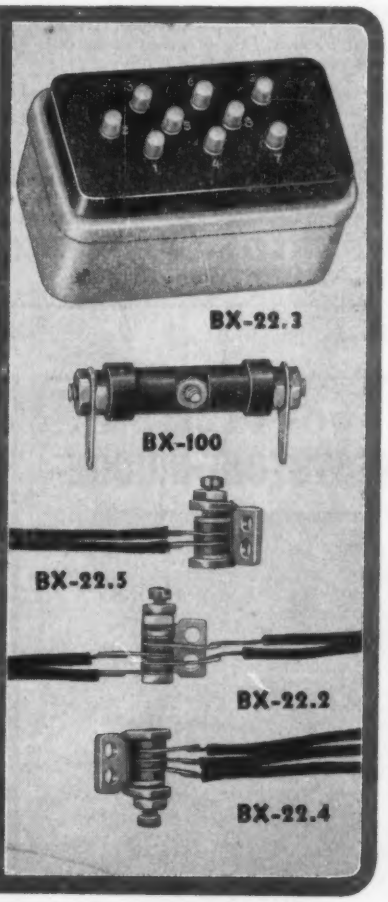
"Coprox" BX-22.3
Double bridge rectifier with current and temperature-current characteristics balanced to better than 1% over a range of −40°C to +70°C. Rated up to 4.5 volts A.C., 3 volts D.C., 5 milliamperes D.C.

"Coprox" BX-100
Center tap, full wave rectifier. Completely enclosed in Bakelite. Low capacitance. Rectifies high frequency current. Rated up to 4.5 volts A.C., 3.0 volts D.C., 500 microamperes D.C.

"Coprox" BX-22.5
Single half-wave rectifier rated up to 4.5 volts A.C., 3.0 volts D.C., 2.5 milliamperes D.C.

"Coprox" BX-22.2
Full wave rectifier rated up to 4.5 volts A.C., 3.0 volts D.C., 5 milliamperes D.C.

"Coprox" BX-22.4
Double half-wave rectifier rated up to 4.5 volts A.C., 3.0 volts D.C., 2.5 milliamperes D.C.



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THE MODEL 610-B

MEG-O-METER

A New Battery Operated

INSULATION TESTER!!

Instantly measures the exact leakage of all insulation up to—

200 MEGOHMS

At a test potential of

500 VOLTS D. C.

Supplied by a built-in battery and vibrator power supply.

SPECIFICATIONS:

- NO HAND CRANKING—The 500 VOLT POTENTIAL is made instantly available by simply throwing a front panel toggle switch.
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- 3 RANGES: 0 - 20,000 Ohms, 0 - 2 Megohms and 0 - 200 Megohms.
- The instrument is housed in a heavy-duty Oak portable cabinet.
- Panel is of solid bakelite engraved by the new "cut-in" process which eliminates possibility of letters being scratched off.
- Meter movement—a 4½" 0 to 200 Microampere sensitive meter guarantees extremely accurate readings on all ranges.

Model 610-B comes housed in a beautiful, hand-rubbed Oak cabinet complete with cover, self-contained batteries, test leads and instructions. Size 9½" x 8½" x 6". Shipping weight 16 pounds. Price...

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WHEATSTONE BRIDGE

A high grade instrument for measuring resistances from a fraction of an ohm to 10 megohms. Contains a 4-dial rheostat, ratio dial, galvanometer and battery, all enclosed in a substantial walnut case. Nine coils per dial. Accuracy .1%. Built to endure.

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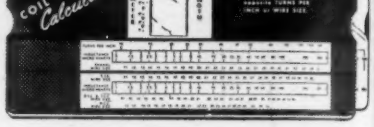
screen. About 300 exposures can be mad on a single 50-foot continuous roll of film In order to adapt the unit to production lines without endangering personnel it i in two sections, designed so that no specia lead-lined surroundings are needed. Water cooled X-ray tube is contained in upper head which is automatically controlled. Thi head must telescope and fit exactly with the lower section before an exposure can be made. Manufacturer's announcement em phasizes that industrial radiographic equip ment of this type, although limited to cer tain varieties and sizes of product, is o particular importance at this time. De signers are stripping models of every par that does not contribute to strength o function. This makes it all the more neces sary that flaws be detected early in manu facturing.—*Westinghouse Elec. & Mfg. Co. East Pittsburgh, Pa.*

Coil-winding and R-f. Resonance Calculator

New slide-rule type rapid calculator per mits quick and accurate determination o inductance, capacitance, and frequency com ponents of series or parallel tuned r-f. cir



cuits as well as inductance, turns-per-inch wire type, wire size, coil diameter and coi length for single layer-wound solonoid type r-f. coils. All values, in either case, are found with a single setting of the slide and are accurate to within approximately 1% for coils ranging from ½" to 5½" in diam eter and ¼" to 10" in length. All possible combinations within these limits are shown Wire types and sizes include 11 to 35-gage plain enamel, 11 to 36-gage S.S.C., D.S.C. and S.C.C., and 12 to 36 gage D.C.C. The rule is also engineered to indicate: turns per-inch from 10 to 160; inductance from 0.1 to 15 microhenrys; capacitance from 3 to 1.000 $\mu\mu$fd; frequencies from 400 kc. to 150 Mc. with equivalent wavelengths in meters.—*Allied Radio Corp., 833 West Jack son Blvd., Chicago 7, Ill.*

Slide Chart for Shop Measurements

Front side of new Elemoto Slide Chart Fig. 1, shows U. S. Standard dimensions fo coarse and fine thread series. When the slide inside the housing is moved to the right or left, the standard dimensions fo each size from #0 to 1¼" are placed at the windows in the blueprint dimension draw

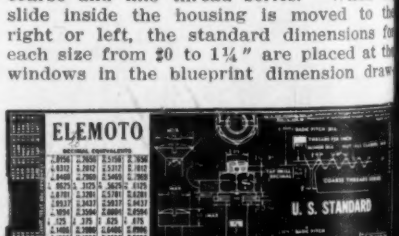


Fig. 1

ings. All required dimensions such a threads per inch, major and minor diam eters, head sizes, etc., are instantly ob tained with one reading. Data were ob tained from U. S. Gov't publication, "Screw Thread Standards for Federal Services." For convenience, this side of the slide hous ing also carries decimal equivalents of frac tion and a table of U. S. Standard Gage

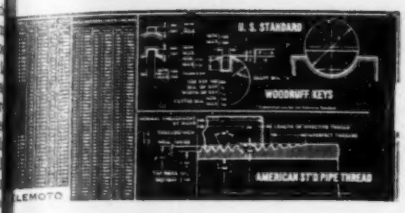


Fig. 2

Steel Sheets. *Reverse* side, Fig. 2, is ed to obtain dimensions for U. S. Stand- d (and other commercial sizes) Woodruff eys; lower section of the slide chart is ed to determine dimensions for American andard Pipe Threads. Housing on this de also carries a table for changing milli- eters to inches and a table of Twist Drill d Steel Wire Gages. This slide chart is w, not comparable with the one brought t last year. New features are two color ide; water resistant and washable sur- ce; improved and more durable construc- on; data revised to correspond with latest overnment publications.—*The Elemoto Sales o., Teaneck, N. J.*

D-c. Voltage Standard Supply

New "Model BX-10048 D-c. Voltage tandard Supply" is a self-contained panel nit developed to give, from any a-c. 60- ycle source, a highly filtered d-c. supply nd an accurate standard for those who re engaged in testing, calibrating and ervicing d-c. voltmeters and low-range

illiammeters. Indicator mounted on panel ndicates voltage of supply selections with anges as follows: 0 to 50 millivolts, 0 to volts, 0 to 50 volts, 0 to 250 volts, 0 to 00 volts, 0 to 200 milliamperes. Unit is quipped with three controls so that voltage election is sensitive at all ranges; and with wo sets of jacks so that panel may be sed with another d-c. standard and any nstruments to be tested or calibrated. What s said to be a unique feature is incorpo- ated in this panel for protection of indi- ator. Selection of ranges is made by plug ack selection so that range multipliers are elected as ranges are selected, making it mpossible for errors in voltage selection o damage the standard. Indicator includes hand-calibrated dial with mirror scales ith accuracies of 0.5%. Pilot light pre- ents power being left on when not in use. New panel is said to do away with main- enance problems that go with the use of atteries. Panel is of ¼" Bakelite, 14" high nd 6¾" wide. It is engraved with most of he operating instructions. Case is heavy teel with baked crackle finish. All acces- ories on panel are removable. Tests have hown that ripple of rectification is practi- ally nil and that any difference in volt- meter readings between this power supply nd straight d-c. voltage is not noticeable.— *Hammett Electric Mfg. Co., 2558 McGee Trafficway, Kansas City 8, Mo.*

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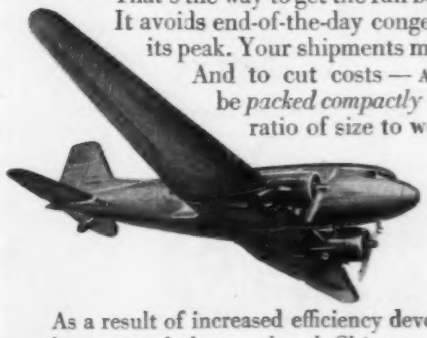

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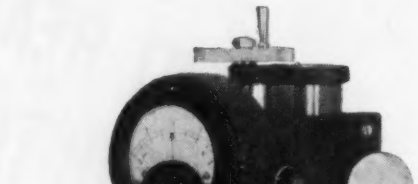

Superior to all types of mechanical and simple electric gages for production inspections.

Culmination of years of experience in comparator instrument design.

Multi-Range Sensitivity: Turning a knob thru three positive ranges (staging the magnification with electronic tubes) permits measurements from "shop thousandths" to millionths of an inch.

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Hathaway INSTRUMENTS

EDITORIAL

(Concluded from page 81)

normalized at a certain temperature. The plane is not passed safe for flying unless evidence is forthcoming that the normalizing was correct, and this is furnished by a temperature recorder. At the same time, to make research pay, it has become necessary to attain bigger production so as to spread the cost. This means bigger plant, more raw material per batch, the use of higher steam pressures and voltages, and co-ordinated production. A few years ago an individual could steer material through a factory by touch and by judgment, relying largely on experience and instinct, and excellent were the results very often. Today huge plants handle masses of material at temperatures, pressures and speeds far beyond the range of human judgment. The catalysis of synthetic rubber, or the tempering of steel are mathematical equations come to life, and to control them mathematics itself must come to life.

So was born Instrument Technology.

(6) Our research chemists and physicists determine the conditions under which eucalyptus timber will pulp, our engineers build the plant to do it; the forester grows the timber; the printer offers to buy the paper. But the plant operators cannot reproduce the conditions specified by the research men without instruments. Those instruments must be selected, they must be installed, they must be maintained, and their readings must be interpreted.

So are born Instrument Technologists.

(7) So surprising have been the results of research that industry has set out to discover all it can, and there is no important industry today that stands aloof. Some factories maintain their own research staffs, others combine in the common cause, whilst others depend on commercial enterprise to supply improved plant and methods.

It often happens, and it happens more often each year, that research produces a formula for improved productions; and that plant manufacturers can design and make the necessary plant, but that the new method calls for the measurement of some entirely new and often very "slippery" physical quantity.

> "Among the properties that the physicist in industry will be called upon to measure are many that have never been properly defined."*

(8) A few years ago instrument manufacturers simply turned down inquiries on these lines. But they have been forced to face the situation and an entirely new method of tackling the problem has evolved. It has been found that instruments can be made to measure and control automatically physical quantities almost without limit. Very often an instrument controls very accurately some process variable, although science has not been able to discover just what the variable is, nor to define its measurement. The measurement of pH value is an instance rather on these lines.

The instrument manufacturers often find that one of their standard designs can be re-wired, or combined with some other instrument, so as to show a deflection, when some condition associated with the process changes.

(9) Apart from the translation of the results of research into practice, there are other developments that are leading to the continuous increase of the use of industrial instruments. One of these, partly the result of the increasing size and complexity of plants, is that operators do not require to know all about the process. Their work is to attend to some one or two pieces of plant, their judgment is of no use in the process, and they are not in a position to regulate conditions except to an arbitrary formula. It is not only simple, it is much more efficient, to say to the night shift "Keep that pressure gage at 42" rather than "Keep that kettle just on the boil." It is now possible to employ men on useful work of this sort who would have been incapable of it before, because anyone can be taught to read a pressure gage reasonably accurately, but a big new factory

* R.C.L. Bosworth: "The Physicist in the Chemical Industry," *Journal of Scientific Instruments*, Sept. 1943.

uld not possibly start up if each man ad to be trained to judge right and rong conditions: no two of them would e working to the same standards.

(10) Instrument manufacturers have ccumulated a fund of information bout industrial measurements, and bout what will and will not work. erhaps they do not always know why will not work, but they are pre-ared to find a way. The result is that, o far as getting practical results goes, nstrument manufacturers possess far nd away more information than any-ne else. Quite often their practice is efinitely different to that laid down in he text books and taught in the schools.

(11) When industry wants informa-ion it must turn to these same manu-facturers, who are thus obliged to build p a technical sales organization. In heir own office such an organization is easonably simple, but to see that buy-rs of their equipment in remote dis-ricts and countrys get proper advice s very difficult.

Take the case of an instrument man-facturer in London, whose products re sold in Australia. Suppose he ap-oints an agent in Melbourne with the dea of increasing his sales. After a eriod of canvassing, advertising and o on, the agent gets inquiries from irms who want information, and these nquiries fall into two definite classes. n the one hand are those people who imply want to buy a straightforward iece of equipment for a familiar job, hile on the other hand there are peo-le who are designing a process and ant exact and detailed advice and in-ormation about what they can or can-ot do. In the same class are people ho have a problem and who want help owards its solution.

It is essential for the agent to em-loy a salesman who knows all about he instruments made in London, who an keep abreast of new developments, ho knows enough physics and chemis-ry and engineering to understand what s being done and why, and who can ollow the customer's explanations and ho can think out a solution for him-elf.

Having delivered the instrument to he customer it is essential to see that t is properly installed. A badly in-talled instrument is not only liable to e damaged, but it may give a false eading or a reading that is not prop-rly representative of the process con-itions. Then it is necessary to in-truct the operators in the routine at-ention required.

An agent who is content to refer tech-ical problems back to the manufac-turer in London, and who makes no at-empt to see that instruments are prop-rly installed and cared for, quickly alls out of the race. Customers natu-ally prefer to deal with firms who can iscuss their problems on the spot, and ho will supervise installation.

(12) Thus these agents require to mploy properly trained Instrument echnologists. There has never been a supply of such men and agents have had great difficulty getting staff. Either it is necessary to take a lad and train him, which takes years, or else to take an engineer and make the best one can of him.

(13) There are a certain number of instrument manufacturers in Australia, but they are working out their own problems and have their own staffs available. Undoubtedly they would employ Instrument Technologists trained in schools, but they are not in the same difficulty as agents and importers.

(14) In the last few years there has been a huge increase in the actual number, as well as in the variety and intricacy, of industrial instruments. Factories that previously had a few pressure gages are now bristling with recorders and automatic controllers. A very real difficulty arises, in that the ordinary plant operators and maintenance men do not understand these instruments. Instruments get out of order, or are even smashed just through ignorance. Besides the loss due to the breakage of something that cost, perhaps, £100, there is the very much more vital matter that the control of the process is either ruined or else reduced to a lower efficiency, until a repair can be carried out.

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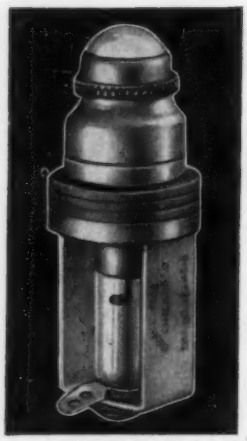
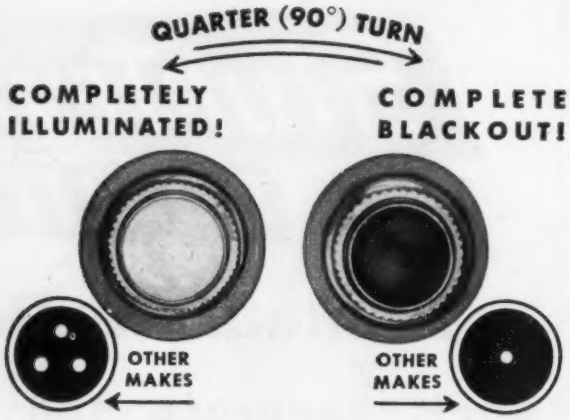
Widely used for testing springs in laboratories and in heat treating, inspection, assembly and repair departments to eliminate costly guesswork in building and maintaining automotive and aircraft motors. (Note: Torque Wrench NOT INCLUDED, unless specified.)

Write for Bulletin ST-13

P.A. STURTEVANT CO.
ADDISON QUALITY ILLINOIS



NEW No. 85
SHUTTER
TYPE



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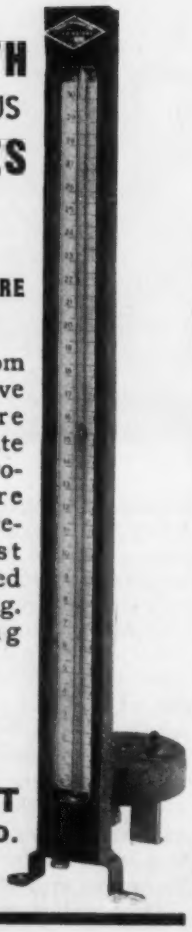

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460 W. 34th STREET, N. Y. C.
ESTABLISHED 1893

firms get inquiries from individu who have been given the job of "lo ing after the instruments" and w want to know how to go about it. desperation, after repeated breaka and losses, the factory appoints so one to take care of the instruments.

(15) The person chosen in this w is practically always a junior chem or apprentice, and he spends some ti perhaps a year or more, finding what he can, more or less by trial a error. It is only after heavy losses t the factory awakes to the realizati that something must be done, and wh the appointment of someone to be sponsible is a good step, the choice an untrained person prolongs the p riod of loss. The cost of breakage probably reduced, but the invisib losses due to low efficiency are almo certain to persist for a long time.

(16) A properly trained Instrume Technologist would be able to save h own salary several times over for a one of a dozen Victorian factorie Some factories have repair bills ru ning into hundreds of pounds, and th lose efficiency to unknown amounts du ing repair. An instrument man cou stop this at once.

(17) Apart from breakage and sim lar mishaps all industrial instrume require some maintenance. There is t work of changing charts of recordi instruments, checking the operation automatic controllers, testing, etc. routine inspections the causes of failu in instruments can be detected and a ticipated, and the life of the instr ments prolonged. Ostensibly the i strument maker is keeping his equi ment in order and thus reducing r pair and replacement bills, in fact h work goes far deeper, because he maintaining the tolerances to which t plant is working.

(18) Instruments control the quali or quantity, they are the limit gag through which the manufactured pro uct must pass. If one instrument is 1 wrong, the entire output passed by th instrument is also wrong. Suppose th mint were to use a weighing machi 1% out, every single coin would b wrong. So it can be seen that instr ments are not just part of the machi ery, they are the brains that contr everything, they are the managers, t executives.

(19) The above lengthy preamble based on actual day-to-day experien in Melbourne over the last ten yea Its purpose is to emphasize that an e tirely new outlook is urgently want on the matter of instruments in indu try, and on education.

It will be noticed that "Instrume Makers" have received scant attenti and reference is more to "Instrume Technologists." That is not to say th there are to be no instrument mak in the plant of the future, far from but they are a different breed.

It is best to separate entirely th two classes, as their work is quite d ferent, they have a different busin

status, and they require quite different training.

Dealing first with our technologist, what are the commercial openings available to him today? And what of the future?

(20) At the present time, partly owing to war conditions, but more because of the lack of trained men, there are at least five good openings available in Melbourne with firms selling imported instruments. There may be four or five times this number, but there are certainly five in decent firms, with first rate prospects, good pay and excellent working conditions. At least one of these firms wants a man to be trained as manager of the technical side of the business by 1950. He would be sent to America or England for experience. The same firm will have openings at intervals of about two or three years, each man going overseas as new ones are engaged. This firm guarantees continuous employment and makes all its employees shareholders after one year's service.

While the above is exceptional, other firms offer positions at least as good as the average run of commercial jobs, and certainly better than for non-technical employes. Owing to the tremendous importance of a correct knowledge of instruments the cost of employing first rate men is an economy, and this is rapidly being realized.

(21) In addition to imported instruments there are also local manufacturers. These would probably absorb a certain number of instrument technologists, but the demand is rather uncertain, because they are either specialists in one class of instruments, or else they are rather haphazard in their methods. Specialist manufacturers can easily train their own staff, owing to the narrower range of knowledge required.

(22) In large public projects, such as power houses, water works, munitions factories, aircraft factories, meteorological services, etc., a very large total number of instruments are used. From the aspect of employment the most significant are the large power houses. The State Electricity Commission of Victoria has recently created a new position "Instrument Engineer" under the Chief Mechanical Engineer. No doubt other large projects will do something similar as time goes on.

(23) In privately owned factories there can be created a large number of openings. Some factories have got out of their difficulties by hit-or-miss methods, and could absorb a number of junior instrument technologists from year to year. Others are struggling to keep new plant on its feet and would absorb at once a man with even a rudimentary instrument training.

Similar conditions will continue after the war; they are not the result of the war, but are merely one of the effects of installing a big plant complete and then putting in a new team of men to run it.

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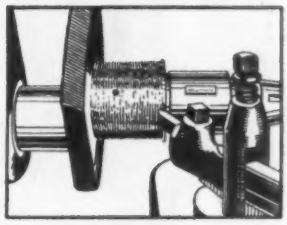
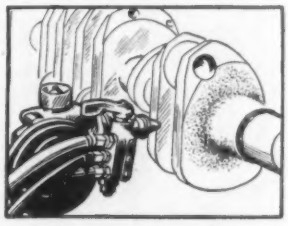


Rough threading—cooling locks metal firmly to surface, producing a permanently tight bond.



Sprayed journal before finishing—Main bearing journal after surface has been Metallized.

Y-101

The number of openings available today and regularly from year to year in factories can hardly be estimated as it will depend partly on the publicity given to Instrument Technology. But a start could be made on the basis of twelve of fifteen annually.

(24) If a proper curriculum is drawn up and the training given meets the actual needs of industry, then there should be no difficulty getting guarantees of employment from big industries. If some form of guarantee is necessary it should be quite easy to approach say thirty or forty firms, and get from them a promise that they will employ fifteen or twenty instrument technologists per annum, as they complete their training, or while they are training. It is possible that the preliminary expense of conducting a training course could be covered by donations from such firms. Some firms would be glad either to give a donation, or else to contribute to an annual subsidy.

(25) The Australian Society of Instrument Technology was founded to clarify the use of industrial instruments, and its membership is largely composed of companies using instruments, firms making or selling instruments, and individuals who are required to care for instruments. It is a non-partisan body and would be competent to assist in the organization of a course of training and it could under-

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ARMY E NAVY

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take to approach industrial concern for donations or subsidies.

(26) Upon completion of his training the instrument technologist should have had a thorough grounding in physics equivalent to 2nd year University pass, also sufficient knowledge in chemistry, mathematics, engineering drawing, English and a little instrument making. But, most important of all, he must have a good training in instrument technology.

No attempt is made in this memorandum to define the hours of study or the approach to the teaching of the familiar subjects, which will readily be handled on existing syllabuses.

(27) To institute teaching of the new subject of instrument technology will be difficult and will call for a good deal of work. One of the worst difficulties will be to get teachers, because the only individuals with the right knowledge are more or less self-taught and their knowledge is largely confined in scope and unsystematised.

This difficulty will be overcome as the teaching class creates its own traditions and systemisation. It may be necessary in the early years to have rather disconnected treatments of different branches of the subject by different teachers.

Care will have to be exercised that teachers have real knowledge. Many instrument engineers are semi-trained men who have picked up fragmentary knowledge. While not denying the very real contribution they can make in practical instruction, they should not be entrusted with educational work beyond their capacity.

(28) The subject covers the principles of design, theory, application, installation, servicing, inspection and repair, all under practical industrial conditions, of instruments.

(29) At this stage it is appropriate to define "Industrial Instruments." Behar's "Manual of Instrumentation" gives the best definition, but it is rather long.*

(30) The teaching of instrument technology will include the following:

(A) *Introductory.* Definition and classification of industrial instruments. Basic principles. Standards. General discussion of indicators, recorders, controllers.

(B) *Elements.* Measuring elements.

---

*"Industrial instruments are devices of rugged construction and practical utility, for measuring or controlling—

"(1) Processing and working *conditions*—1. Temperature, 2. Humidity, 3. Pressure (or vacuum), 4. Duration or Timing, 5. Speed, 6. Flow-rate, 7. Liquid Level, 8. Electrical Conditions, 9. "Strength" (acidity, etc. of processing mediums), 10. Light, u-v rays, X rays, etc.:

"(2) Physical and chemical *properties*;

"(3) Physical and chemical *composition*.

"(4) Miscellaneous other factors, conditions or magnitudes.

"Table I represents a systematic classification . . ."

[The book is out of print but the table was reproduced in *Instruments*, August 1942, page 303.]

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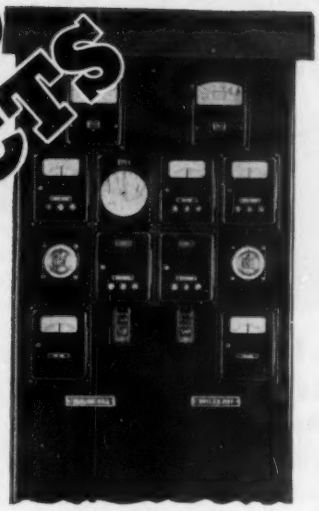

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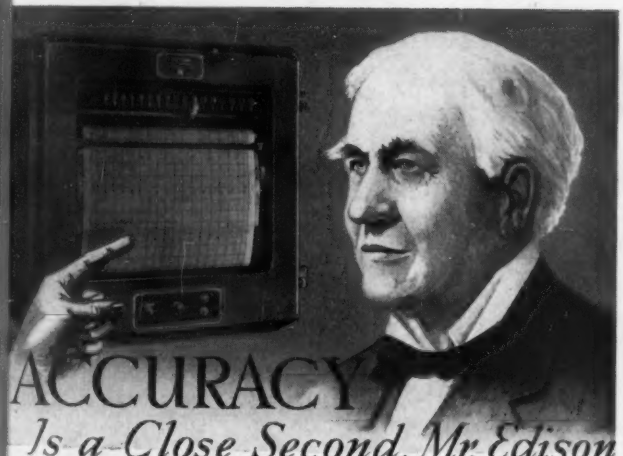

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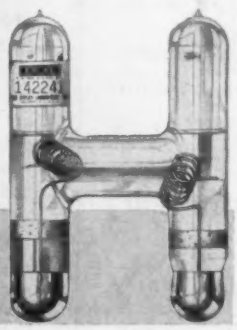

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600,000,000 Strokes
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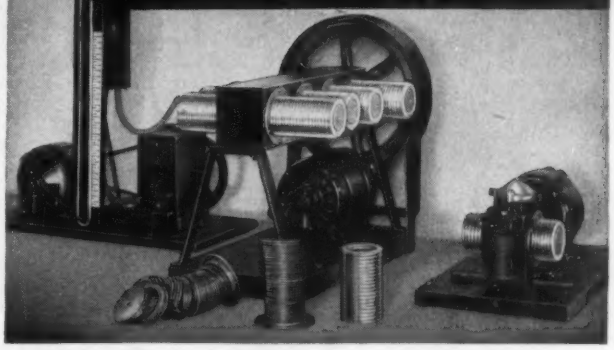

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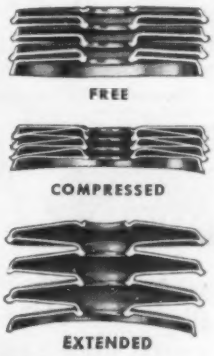

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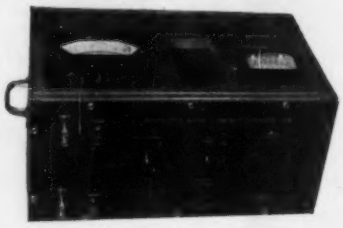

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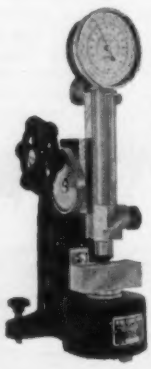

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Sensitivity and accuracy. Sources of error. Interpretation of results.

(C) Mass, length, time, speed.
(D) Pressure.
(E) Temperature.
(F) Recorders.
(G) Controllers.
(H) Humidity.
(I) Fluid flow. Liquid level. Position.
(J) Hydrogen Ion.
(K) Electronics.
(L) Viscosity, density, calorimetry.
(M) Gas analysis.
(N) Electricity.
(O) Optics.
(P) Light, sound, colour.
(Q) Aviation, meteorology.
(R) Telemeters.
(S) Metrology.
(T) Selection, installation, maintenance.
(U) Calibration, acceptance tests, specifications.
(V) Special applications—boiler efficiency, engine tests, research problems, overcoming difficulties, adaption of existing instruments to new problems, etc.
(W) Elements of commercial practice and law of contracts as applied to quotations and purchase of engineering plant. Business ethics.
(X) Planning for the future.

(31) In mapping out the detail under the above Syllabus the most important consideration is that the student should get a comprehensive and sound knowledge of the basic principles underlying the working of instruments. His advanced knowledge of physics will teach him the science but he must also learn the practical ways in which science can be made to give results under working conditions. He should be capable of understanding and explaining the working of any modern automatic device in the instrument class and he should have a general understanding of the classes of error likely to be found in them.

(32) It is most important that the student should learn the practical application of his knowledge by handling typical modern industrial instruments. It would be quite wrong to have too much of the usual laboratory apparatus, he will not have that under his hands in a factory, and he must learn to get the best of the equipment that instrument technology covers.

(33) It will be essential to have a wide range of typical instruments, representing as many different makes as possible. Many of these are fairly obvious, such as thermometers, pressure gages, manometers, dial thermometers, deflection pyrometers, micrometers, slip gages, voltmeters, psychrometers, etc. But the more elaborate instruments, such as potentiometers, recorders, air-operated temperature controllers, steam flow meters, temperature or pressure recorders, etc. are expensive, and may require some auxiliary equipment, such as compressed air supply and fittings, experimental set-ups, etc.

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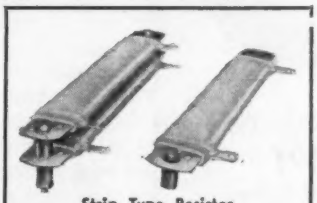

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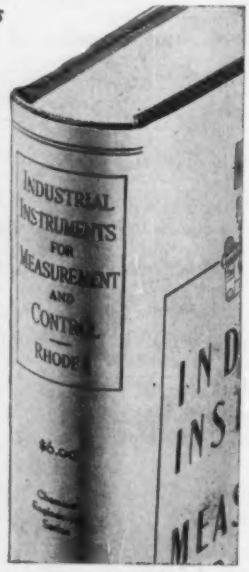
—design and construction of radiation pyrometers;

—how to solve problems in flow measurement;

—liquid-level measurement by means of float gauge instruments;

—telemetering;

—etc., etc.



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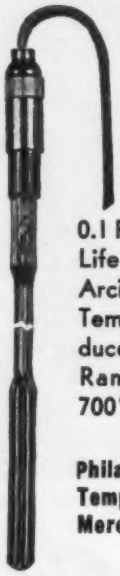

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without this equipment, so the situation must be faced that it must be obtained. Instrument firms should be approached and asked to donate instruments. Failing that, they should be asked to sell at cost, without profit, or at even below cost. Large manufacturing companies should be asked for donations.

Very often, broken instruments will be quite useful for instruction purposes and it should be relatively easy to collect quite a lot at little expense. See Clause (25).

(34) A student who has completed the course should be entitled to credit towards an engineering diploma, and should receive a certificate, or other mark of competency, enabling him to seek employment at once.

A Certificate must be definite evidence that the student is competent to recognize the different types of instrument in a plant, knows how they work, how to test and adjust them and so on.

(35) Having dealt at some length with instrument technology, let us now turn to instrument making. Enough has been written to show that the two subjects are different, and need different treatment. Instrument making is nothing more or less than the making of instruments, that is, it is the trade of fine mechanical engineering, or else of glass apparatus making, or optical instrument making. There are some specialized trades, such as balance making and adjusting, or thermometer making, which absorb a few men, but the great bulk of those trained as instrument makers are engaged on radio and cinema equipment and similar fine work, or else as instrument fitters and repairers for aircraft, water meters, electrical meters and instruments, and so on.

There is a good deal of instrument making for defense at present that will not last after the war.

(36) Experience shows that the small engineering shops that describe themselves as "Instrument Makers" are capable of first class mechanical work. They are quite incapable of designing or making an instrument having specified calibration characteristics. It seems to be a mistake to try to teach too much to students intended for instrument making. They should learn all they possibly can about their trade, but to expect them to master the application of instruments to industry is merely to confuse instrument making with instrument technology. Of course instrument makers must have the basic teaching to enable them to be taught the adjustment of balance, or the welding of thermocouples, but the first thing for them to learn is their trade and craft.

(37) The courses of instrument making and instrument technology should be so arranged that the student who is ambitious can transfer at any stage from the former to the latter. There will be a definite percentage each year who will want to do this.

Students of instrument making should

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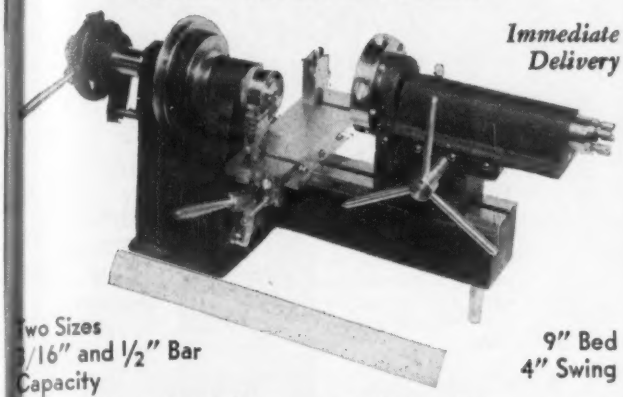

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attend two or three of the technology lectures during the year, lectures of a general or introductory nature. It has already been laid down that technology students must have a little training in instrument making (Clause 26.).

It would be quite possible to draw up a detailed syllabus at once, together with a list of text and reference books.

(38) A lot of attention has been given to this subject in U.S.A., and war has accentuated the difficulties caused by a lack of instrument technologists.

Many Universities and Colleges have instituted training courses, some of high standing, and many with Government support. These have all been a great success and have attracted more students than was expected. Many of these courses are dependent on instrument manufacturers, whose representatives have acted as part time or special subject lecturers. Probably the University courses are mostly within the schools of mechanical or chemical engineering, while the Technical College courses are evening or part time.

Alabama (whether Polytechnic or University not stated) has a 78-hour course. This is for trained engineers and only just suffices to survey the subject briefly. The Case School of Applied Science has a course of 24 lectures. Also might be mentioned Oregon State College, University of Southern California, Illinois Institute of Technology, and many others.

Owing to the increasing complexity of industrial processes, and the closer tolerances required to be maintained by instrumentation, both instrument manufacturers and large users (such as refineries and air lines) found it necessary to train their own men. This led to the establishment of private training schools, long before the Universities and Colleges did anything on the same lines.

The disadvantage of these private schools is that they train men only to serve their own purposes, and their scope is thus too limited, although their training is much more thorough, so far as it goes.

(39) The information in Clause (38) is based largely on numerous articles, mainly in the magazine *Instruments* and the following should be read in conjunction with this memorandum.

BOOKS.

Behar, "Fundamentals of Instrumentation."

Perazich, Schimmel and Rosenberg, "Industrial Instruments and Changing Technology."

ARTICLES.

"Training of Physicists for Industry." Am. Physics Teacher, 1936, 7.

FROM *Instruments* MAGAZINE.

"Training your own Instrument Men." Jan. 1937.

"Industrial Instrument Course at the Charleston Evening Trade School." Apr. 1939.

Editorial, Dec. 1940.

"Case School of Applied Science, lectures on Instrumentation." Dec. 1940.

"Survey of Educational Training Courses." Feb. 1941.

"Instrument Education and Training." Mar. 1942.

"Course for Aircraft Instrument Mechanics." Apr. 1942.

FROM SYMPOSIUM ON TEMPERATURE MEASUREMENT, 1939. AMERACAN INSTITUTE OF PHYSICS.

"Industrial Course in Temperature Measurements."

"Teaching of Pyrometry in Technical Schools."

"Education of a Pyrometrist."

"Instruction in Temperature Measurement to Mechanical Engineering Students."

ALSO

"The Physicist in the Chemical Industry." J. Sci. Insts. Sept. 1943.

"Memorandum on Post-War Education and Training of Physicists," and "Physics in Industry," both from the Institute of Physics "Notices to Members" (not for general publication) May and July 1942.

(40) In conclusion the following are repeated for the sake of emphasis:

(A) Instrument making must be separate from Instrument Technology.

(B) The aims of the course must be essentially practical.

(C) The choice of teachers is vital and should be scrutinized with care.

(D) Industry will give the course ample support, provided that real Instrument Technology is taught.

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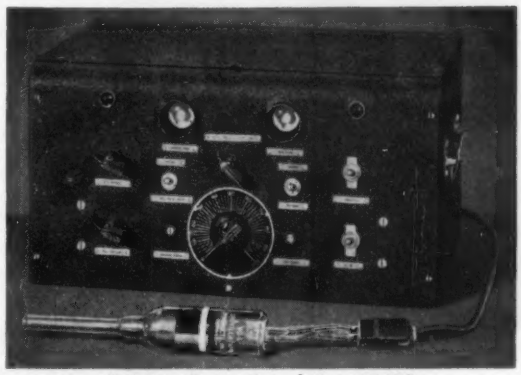

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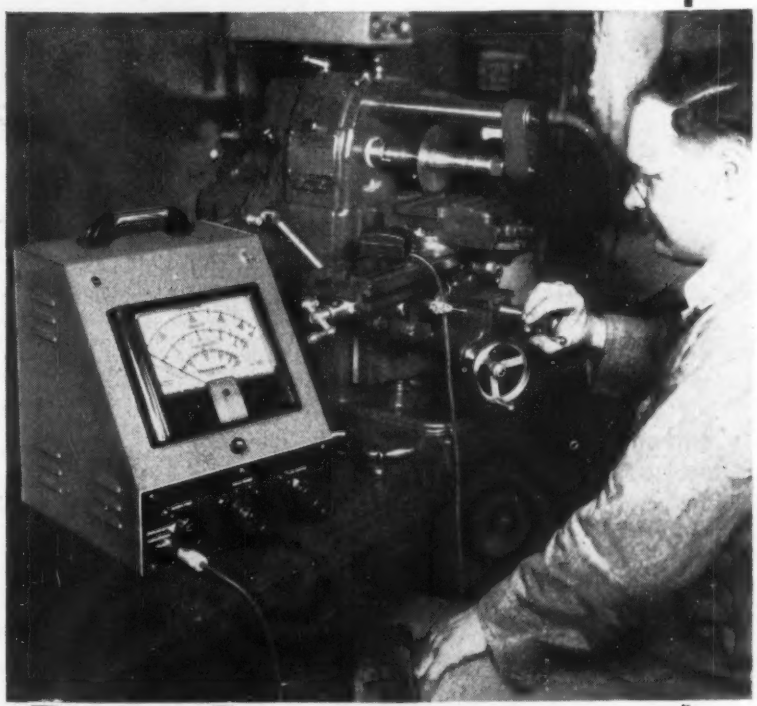

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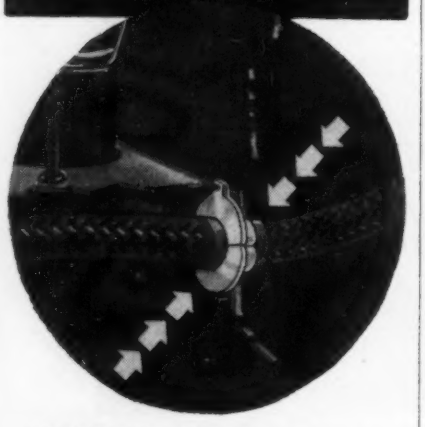

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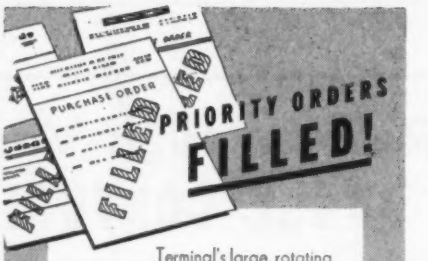

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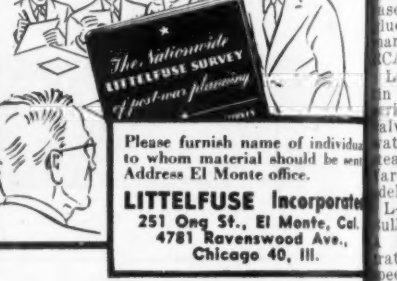

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L-22 **Precision Electronic Photometer.** Booklet, 5½″ × 7½″, 12 pages describes the Ansco Sweet Densitometer, a direct-reading photo-electric instrument designed primarily for the measurement of photographic film densities. Agfa Ansco, Binghamton, N. Y.

L-23 **Feed Water Regulator.** Form 435, 8½″ × 11″, 4 pages lists advantages offered by the Copes Flowmatic. Northern Equipment Co., 1945 Grove Drive, Erie, Pa.

L-24 **Sapphire Plug Gages.** Leaflet, 8½″ × 11″, 2 pages describes sapphire gages which are said to outwear steel gages 30 times. Sapphire Products Div., Elgin National Watch Co., 932 Benton St., Aurora, Ill.

L-25 **The Ohmite News** November 1943 issue features a brief biography of Professor Elihu Thompson, famous pioneer in the field of electricity. Also included are suggestions for ordering resistors. Ohmite Manufacturing Co., 4835-41 Flournoy St., Chicago 44, Ill.

L-26 **The Laboratory.** Booklet, 6″ × 9″, 25 pages, simplifies understanding of WPB Regulations for laboratory supplies. Includes an article on Sub-Sieve Sizer, a new instrument which measures the size of particles too small to be measured by sieves. Fisher Scientific Co., 717 Forbes St., Pittsburgh, Pa.

L-27 **Industrial X-Ray Accessories.** Bulletin, 8½″ × 11″, 13 pages, describes and illustrates x-ray tube units and accessories for industrial inspection of materials and parts. Picker X-Ray Corp., 300 Fourth Ave., New York, N. Y.

L-28 **Aircraft Instrument Test Apparatus.** Leaflet, 8½″ × 11″, 2 pages, illustrates and describes Turn Indicator Test Stand for testing "Rate of Turn" manometers for pressure gauge tests and air speed tests; also includes description of an oscillating table which provides, among other things, a combined motion of roll, pitch, and yaw. Ideal Laboratory Tool and Supply Co., P. O. Box 1[illegible], Cheyenne, Wyoming.

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L-30 **Diesel Engine Pyrometers.** Bulletin P1214, 8″ × 10½″, four pages, covers diesel engine pyrometric equipment and accessories designed especially for marine applications. Bristol Company, Waterbury, Conn.

L-31 **2½-Inch Panel Instrument.** Publication GEA-4117, 8″ × 10½″, [illegible] pages, provides information on the internal-pivot type of aircraft instrument for naval aircraft applications. Illustrations include complete instruments, construction details, and dimensions. A[illegible]

ives list prices as well as applicable AAF part numbers. General Electric Co., Schenectary, N. Y.

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L-34 **Industrial Analyzer, Insulation Tester, and Multimeter.** Folder, 7" × 10½", 4 pages. Announces manufacture of new models of above instruments. Superior Instruments Co., 227 Fulton St., New York 7, N. Y.

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L-36 **Steam Plant Equipment.** Bulletin G-1306, 8½" × 11", 12 pages, describes blow-off and tandem blow-off valves for boilers; water columns and water level gages; expansion joints for steam lines; and other related equipment. Yarnall-Waring Co., Chestnut Hill, Philadelphia, Pa.

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L-40 **Instruments for Automatic Control of War-Time Processes and Operations.** Bulletin DM 006, 9¼" × 12", 2 pages, describing manufacturer's line of automatic control and recording instruments. Bristol Co., Waterbury 91, Conn.

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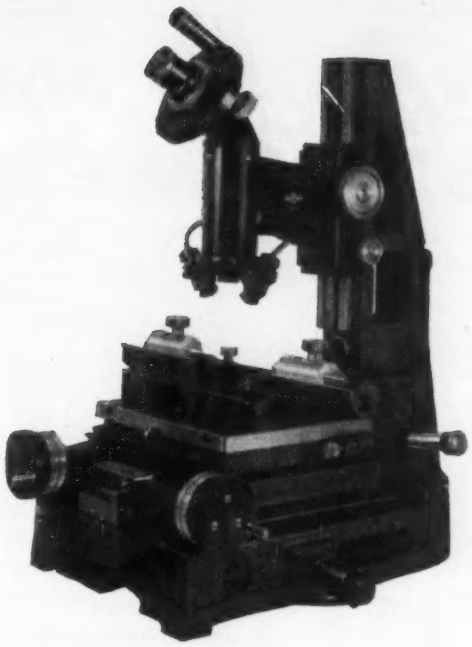

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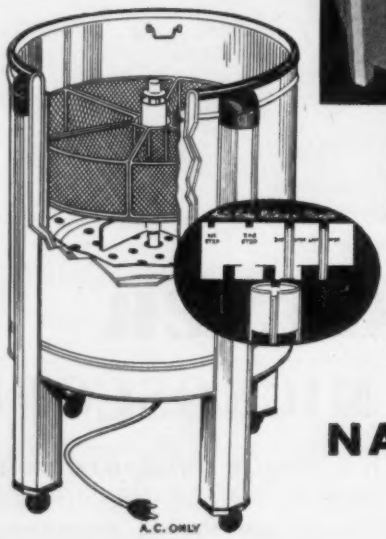

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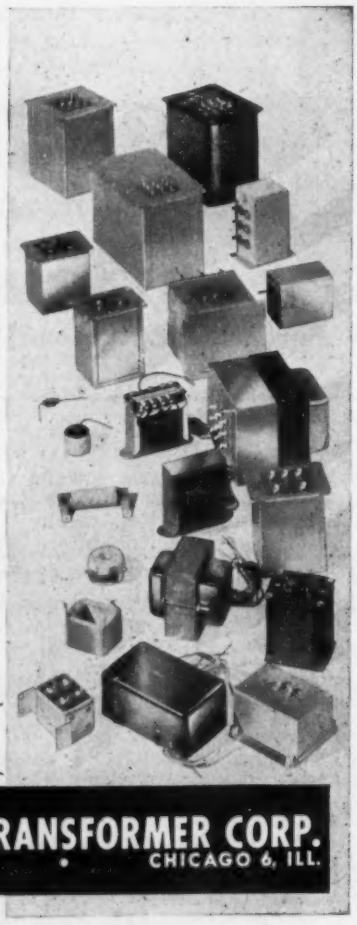

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